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(54) DATA PROCESSING APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To specify a watermarked material item with high probability and to lower the probability of missing.
SOLUTION: One code word in a set of prescribed code words is introduced to a copy of an original material item, and a watermarked version of the original material item is created. The code word is generated by a pseudo random number generator which is initialized by a seed value. The seed value is used for the purpose of specifying the watermarked material item from the code word generated by the seed value. The code word is reproduced from the watermarked material item, all code words in the set of code words are made correlative with a reproduced code word, and the specific copy of the watermarked material item is detected.

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CLAIMS

[Claim(s)]

[Claim 1]

In the detection data processor which identifies the group of one or more predetermined codewords which exist in the version to which the water mark of an original material item was given generated by combining each codeword multiplier corresponding to each sample of an original material, respectively,

The registration processor which relates the sample of the version to which the water mark of the above-mentioned original material item was given with the sample to which the original material item with which the above-mentioned codeword multiplier which carries out correspondence was combined corresponds,

The playback processor which reproduces a codeword and generates a playback codeword by comparing the sample of the above-mentioned original material item with the sample to which the version to which the above-mentioned water mark was given corresponds,

The correlation processor which generates a correlation value by making the above-mentioned playback codeword and the generated codeword correlate about each codeword in the group of the above-mentioned predetermined codeword,

The detection data processor equipped with the detection processor which detects one or more codewords based on the correlation value exceeding a predetermined

threshold of a codeword.
[Claim 2]
The above-mentioned registration processor,
About the sample of the above-mentioned original material item, and the sample of the version to which the above-mentioned water mark was given, a correlation value is computed for each [to the version to which this water mark of the sample of this original material item was given] the shift of every,
The 1st [to the version to which the above-mentioned water mark was given] registration location in the above-mentioned original material item is judged from the shift which shows the highest correlation value among each above-mentioned shift,
The exaggerated sampling of the version to which the above-mentioned original material item and the above-mentioned water mark were given is carried out,
About the version by which the exaggerated sampling of the version to which the sample and the above-mentioned water mark of the above-mentioned original material item were given was carried out, a correlation value is computed for each [to the registration location of the above 1st] the shift of every,
The detection data processor according to claim 1 characterized by judging the 2nd registration location from the shift which shows the highest correlation value among each shift of a version by which the exaggerated sampling was carried out [above-mentioned].
[Claim 3]
The above-mentioned registration processor,
About the registration location of the above 2nd, the difference between each sample of the above-mentioned original material item and each sample to which the version to which the above-mentioned water mark was given corresponds is computed,
the above -- difference -- a predetermined threshold -- comparing -- this -- the detection data processor according to claim 1 or 2 characterized by permuting the sample of the version to which the this registered water mark was given by the sample to which the above-mentioned original material item corresponds when difference is over this threshold.
[Claim 4]
They are claim 1 which the above-mentioned correlation processor is equipped with the codeword generation machine which generates the pseudo-random number for generating a playback codeword multiplier, and is characterized by generating this pseudo-random number from the seed value generated based on the sample of the version to which the above-mentioned water mark was given thru/or a detection data processor given in 3 any 1 terms.
[Claim 5]
It is introduced into a material item in a discrete cosine transform field, and the above-mentioned codeword is the detection data processor concerned,
When it has the discrete cosine transform processor which changes into a discrete

cosine transform field the version to which the above-mentioned water mark was given, and an original material item and the above-mentioned playback processor subtracts the discrete cosine transform multiplier to which the version to which the above-mentioned water mark was given corresponds from the discrete cosine transform multiplier of the above-mentioned original material item, they are claim 1 characterized by generating the above-mentioned playback codeword thru/or a detection data processor given in 4 any 1 terms.

[Claim 6]

In the coded data processor which generates the version to which at least one water mark of this original material item was given by introducing one codeword in the group of a predetermined codeword into the copy of an original material item,

The codeword generation machine which generates the codeword which has two or more codeword multipliers from the predetermined group of the above-mentioned codeword,

Each above-mentioned codeword multiplier is combined with two or more samples to which the above-mentioned original material item corresponds, and it has the coding processor which generates the version to which the above-mentioned water mark was given,

It is the coded data processor characterized by for the above-mentioned codeword being generated by this codeword using the pseudo-random number generation machine initialized by the seed value related with the proper, and generating the above-mentioned codeword multiplier from the numeric value generated with this pseudo-random number generation vessel.

[Claim 7]

The above-mentioned codeword generation machine is a coded data processor according to claim 6 characterized by generating the above-mentioned seed value from the sample of the above-mentioned material item.

[Claim 8]

The discrete cosine transform processor which changes the above-mentioned material item into a discrete cosine transform field,

The material item of the above-mentioned discrete cosine transform field It is expressed by two or more discrete cosine multipliers. The above-mentioned coding processor By adding one of the above-mentioned codeword multiplier and the corresponding discrete cosine transform multipliers By combining the above-mentioned codeword multiplier and the above-mentioned material item, and carrying out the reverse discrete cosine transform of the image with which the above-mentioned codeword was added by this coding processor and by which the discrete cosine transform was carried out [above-mentioned] A coded data processor [equipped with the reverse discrete cosine transform processor which generates the version to which the water mark of the above-mentioned material item was given] according to claim 6 or 7.

[Claim 9]

Projection equipment equipped with claim 6 which at least one of an audio signal and picture signals is supplied, and introduces a codeword into at least one of this audio signal and picture signals before copy processing thru/or a coded data processor given in 8 any 1 terms.

[Claim 10]

A web server equipped with claim 6 which it is the web server which offers the material item downloaded through the Internet, this material item is supplied before this material item downloads, and introduces a codeword into this material item thru/or a coded data processor given in 8 any 1 terms.

[Claim 11]

In the addressee specification system which specifies the addressee of a material item,

Claim 6 which generates the material item to which the water mark was given by introducing into a material item the codeword generated from the seed value which specifies the above-mentioned addressee as a proper thru/or a coded data processor given in 8 any 1 terms,

An addressee specification system equipped with claim 1 which detects the addressee of this material item by predetermined incorrect detection probability by detecting the existence of the codeword in the above-mentioned material item thru/or a detection data processor given in 6 any 1 terms.

[Claim 12]

In the discernment approach of identifying the group of one or more predetermined codewords which exist in the version to which the water mark of an original material item was given generated by combining each codeword multiplier corresponding to each sample of an original material, respectively,

The step which relates the sample of the version to which the water mark of the above-mentioned original material item was given with the sample to which the original material item with which the above-mentioned codeword multiplier which carries out correspondence was combined corresponds,

The step which reproduces a codeword and generates a playback codeword by comparing the sample of the above-mentioned original material item with the sample to which the version to which the above-mentioned water mark was given corresponds,

The step which generates a correlation value by making the above-mentioned playback codeword and the generated codeword correlate about each codeword in the group of the above-mentioned predetermined codeword,

The discernment approach of having the step which detects one or more codewords based on the correlation value exceeding a predetermined threshold of a codeword.

[Claim 13]

In the water mark addition approach which generates the version to which at least one water mark of this original material item was given by introducing one codeword in the group of a predetermined codeword into the copy of an original material item,

The step which generates the codeword which has two or more codeword multipliers from the predetermined group of the above-mentioned codeword,
Each above-mentioned codeword multiplier is combined with two or more samples to which the above-mentioned original material item corresponds, and it has the step which generates the version to which the above-mentioned water mark was given,
The step which generates the above-mentioned codeword,
The step which initializes a pseudo-random number generation machine with the seed value related with the above-mentioned codeword by the proper,
The water mark addition approach characterized by having the step which generates the above-mentioned codeword multiplier from the numeric value generated with the above-mentioned pseudo-random number generation vessel.
[Claim 14]
The data signal showing the material item to which the codeword was added by claim 6 thru/or the coded data processor given in 8 any 1 terms.
[Claim 15]
Data medium with which the data signal according to claim 14 was recorded.
[Claim 16]
The computer program which offers the instruction which can be executed by computer which it is loaded [computer] to a data processor and operates this data processor as claim 1 thru/or a detection data processor given in 5 any 1 terms or claim 6 thru/or a coded data processor given in 8 any 1 terms.
[Claim 17]
The computer program which offers the instruction which can be executed by computer which it is loaded [computer] to a data processor and makes this data processor perform an approach according to claim 12 or 13.
[Claim 18]
The computer program product equipped with the medium which can be read by computer by which the information signal showing a computer program according to claim 16 or 17 is recorded.
[Claim 19]
The receiving set which combines with this input signal at least one codeword which is the receiving set which receives the signal showing a material item, is equipped with claim 6 thru/or a coded data processor given in 8 any 1 terms, and identifies an input signal to a proper.
[Claim 20]
The detection data processor or coded data processor explained below with reference to an attached drawing.
[Claim 21]
The discernment approach or the water mark addition approach explained below with reference to an attached drawing.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]
This invention relates to the coded data processor and approach of embedding a codeword (code words) at the version of a material item. In some applications, a codeword is used in order to identify a material item. Corresponding to this, this invention relates to the data processor and approach of detecting one or more codewords embedded at the material item.
[0002]
[Description of the Prior Art]
In order to identify a material, the processing which embeds information to a material is called water marking processing.
[0003]
A discernment codeword is embedded at the version of a material item, in order to identify the version of a material item. That is, the addressee of the specific version of a material can be specified by water marking processing. Here, when a material is copied or used for the intention of the distribution person of a material in a not suitable form, a distribution person can specify the version of a material from a discernment codeword, and can take a suitable cure.
[0004]
the material item which set on these specifications, and was copied or used for the intention of the feeder of a material, an owner, an implementer, or a distribution person in the not suitable form -- expedient -- the OFENDINGU item (offending item) of a material, or OFENDINGUMATE -- being real (offending material) -- it calls.
[0005]
Materials may be any of a material (information bearing material) including a video material, an audio material, an audio / video material, a software program, a digital document, and what kind of information.
[0006]
In order to make the structure of a water mark successful, it needs to be difficult for a user to remove identification code as much as possible. Moreover, it also needs to be difficult for a user to change identification code and to show others the implementer of the OFENDINGU item of a material as much as possible. An alteration as whose mask of a codeword or codeword by such user shows other users is called a KORUJON attack (collusion attack).
[0007]
[Problem(s) to be Solved by the Invention]
It is necessary to make it it become difficult in the structure of all water marks for the user who received the copy of the same material to succeed in a KORUJON

attack. Therefore, the structure of a water mark needs to be what can specify the material item to which the water mark set as the object of a KORUJON attack is given by the high probability. this specification -- OFENDINGUMATE -- since real, it realizes by identifying the reproduced codeword. The probability (overlooking probability: false negative probability) judged as on the other hand a codeword not existing in a codeword existing must be low. Furthermore, the probability (incorrect detection probability: false positive probability) judge that is the user who performed the malfeasance accidentally [user / who has not participated in a KORUJON attack in fact] must be made as low as possible.

[0008]

U.S. Pat. No. 5664018 is indicating the water marking processing which attaches the digital water mark created from the codeword which has the multiplier of a predetermined number from a material to two or more copies. The material item to which a water mark is given is an image. The equipment which performs **** of the water mark currently indicated here changes an image into a discrete cosine transform (it is called DCT below Discrete Cosine Transform:.) field. A digital water mark has normal distribution and consists of groups of a multiplier distributed at random. In a DCT field, each codeword multiplier corresponding to each DCT multiplier is added, respectively. The detailed mathematical analysis of this water marking processing for preventing an attack is indicated by July 27, 1998 which is the reference relevant to this, Jay Kilian (J. Kilian) published from MIT, EFU tea Layton (F. T.Leighton) work, and "protection (Resistance of Digital Watermarks to Collusion Attacks) of the digital water mark to a KORUJON attack."

[0009]

[Means for Solving the Problem]

As the 1st side face of this invention, this invention offers the detection data processor which identifies the group of one or more predetermined codewords which exist in the version to which the water mark of an original material item was given. The version to which the water mark was given is generated by combining each codeword multiplier corresponding to two or more samples of each of an original material, respectively. A detection data processor is equipped with the registration processor which relates the sample of the version to which the water mark of an original material item was given with the sample to which the original material item with which the corresponding codeword multiplier was combined corresponds. A detection data processor by comparing the sample of an original material item with the sample to which the version to which the water mark was given corresponds further The playback processor which reproduces a codeword and generates a playback codeword, The correlation processor which generates a correlation value by making a playback codeword and the generated codeword correlate about each codeword in the group of a predetermined codeword, Based on the correlation value exceeding a predetermined threshold of a codeword, it has the detection processor which detects one or more codewords.

[0010]
As the 2nd side face of this invention, this invention offers the coded data processor which generates the version to which at least one water mark of an original material item was given by introducing one codeword in the group of a predetermined codeword into the copy of an original material item. A coded data processor is equipped with the codeword generation machine which generates the codeword which has two or more codeword multipliers from the predetermined group of a codeword. Furthermore, a coded data processor combines each codeword multiplier with two or more samples to which an original material item corresponds, and is equipped with the coding processor which generates the version to which the water mark was given. A codeword generation machine is equipped with a pseudo-random number generation machine. A codeword generation machine initializes a pseudo-random number generation machine with the seed value related with the codeword by the proper, and generates a codeword from the numeric value generated with the pseudo-random number generation vessel.
[0011]
This invention aims at offering the realistic water mark system using the codeword which has a multiplier which is indicated by U.S. Pat. No. 5664018, and which was distributed at random. In this invention, the pseudo-random number generation machine which constitutes some of detection data processors and coded data processors is used. A pseudo-random number generation machine determines the sequence of the numeric value to which a pseudo-random number generation machine generates a seed value using a seed value. The seed value is related with the version of the material item to which the water mark where the codeword generated from this seed value was embedded was given by the proper. Therefore, the version of the material item to which the water mark was given can be easily specified with this seed value.
[0012]
The detection data processor based on this invention is equipped with a registration processor. By the registration processor, the engine performance of a detection data processor becomes still higher. By making the version to which the water mark of a material item was given correspond to the original copy of a material item, and registering it, the probability for existence of a codeword to be detectable becomes high, and can lower a overlooking probability (false negative probability). It is because the sample of the material item to which, as for this, the water mark was given has high possibility of corresponding to the sample of an original material item, so the probability which can reproduce a codeword becomes high.
[0013]
In the desirable example of this invention, the seed value of a codeword is drawn from the value of the sample of an original material item. It becomes unnecessary thereby, to send and receive the seed value over each codeword between a coded data processor and a detection data processor.

[0014]
The further side face and the further description of this invention are defined in the attached claim.
[0015]
[Embodiment of the Invention]
A general view of a water mark system
Hereafter, the gestalt of operation of this invention is related to protection of a video image, and it explains. The number of copies is determined by the number of the users who should distribute a video image. The discernment codeword (identification code word) for identifying the copy assigned to one of these users is added to each copy.
[0016]
A video image is one example of the material protected by embedding a digital codeword. The material protected by embedding a codeword may be a material including a software program, a digital document, music, an audio signal, and what other kinds of information other than a video image.
[0017]
Drawing 1 is the block diagram showing the concrete configuration of the coded-image processor (encoding image processing apparatus) which introduces a discernment codeword into the copy of an original image. The original image I is supplied from the source and saved at a frame memory 1. This original image is copied as two or more copies to which the water mark was given (reproduce), and the discernment codeword of a proper is given to each copy. An original image is supplied to the DCT processor 2, and the DCT processor 2 divides an original image into the pixel block of 8x8, and performs DCT processing to each pixel block of 8x8. Thereby, the DCT processor 2 generates the DCT resolution picture V.
[0018]
In the following explanation, the vocabulary a "sample" shall point out the discrete sample which constitutes an image (or you may be the material of other classes in fact.). A sample may be a brightness sample of the image which can be copied also from a pixel. Therefore, vocabulary called a sample and vocabulary called a pixel may be exchangeable depending on a situation.
[0019]
The DCT image V is supplied to the coding processor (henceforth an encoder) 4. The discernment codeword is also supplied to the coding processor 4 from the discernment codeword generation machine 8.
[0020]
Two or more seed values (seed) are supplied to the discernment codeword generation machine 8. Each seed value is used in order to generate one of the discernment codewords which correspond, respectively. Each generated discernment codeword is embedded to the copy of an original image, and the image to which the water mark was given by this is generated. The discernment codeword

generation machine 8 is equipped with a pseudo-random number generation machine. A pseudo-random number generation machine generates the codeword multiplier for forming a specific discernment codeword. In a desirable example, a codeword multiplier is generated based on normal distribution. In addition, it may replace with this and a codeword multiplier may be beforehand defined based on the seed value used since a pseudo-random number generation machine is initialized. Therefore, a corresponding seed value exists in each discernment codeword, and each seed value is memorized by memory 12. That is, in order to generate the discernment codeword Xi, the seed value seedi is read from memory 12, and the pseudo-random number generation machine in the discernment codeword generation machine 8 is initialized using this seed value seedi.

[0021]

The DCT version of an original image is expressed in the following explanation as V. It is here,

V={vi}= {v1, v2, v3, v4, ..., vN}

It comes out, and it is and vi is the DCT multiplier of an image. In other examples, vi is the sampled value of an image and may express the sampled value of the image in the sampled value of an image in a space field, or other fields.

[0022]

Each discernment codeword Xi consists of codeword multipliers of n pieces as follows.

Xi={xij}= {xi1, xi2, xi3, xi4, ..., xin}

Several n of a codeword multiplier corresponds to the measurement size of the original image V. In addition, the number of multipliers may differ and this number may be determined according to specific application.

[0023]

And the vector of the codeword multiplier which constitutes the i-th discernment codeword Xi is supplied to an encoder 4 through a channel 14. An encoder 4 generates the image Wi to which the water mark was given by adding the discernment codeword Xi to Image V. In fact, as shown in the following formulas, the image Wi to which the water mark was given is generated by applying each codeword multiplier to each multiplier of an image.

Wi=V+Xi

Wi=v1+xi1, v2+xi2, v3+xi3, v4+xi4, ..., vn+xin

As shown in drawing 1 , the image Wi to which the water mark was given is outputted by it from this image processing system, after reverse DCT conversion is carried out by the reverse DCT processor 18 which carries out reverse DCT conversion of the image generated by the encoder 4.

[0024]

Therefore, as shown in drawing 1 , from an encoder 4, the group of the image to which the water mark was given is outputted. If data word is made into a maximum of 20 bits, one of the 10 million discernment codewords can be chosen, and the

version Wi to which 10 million water marks were given can be generated to an original image.

[0025]

Although the copy Wi to which the water mark of Image I was given is discriminable according to an individual with this discernment codeword, in other examples, data can be sent within an image by above-mentioned 20 bits. Therefore, 20 bits of payloads of 20 bits for sending data within Image V used in order to choose a discernment codeword so that it may explain below are offered.

[0026]

The coded-image processor which is shown in drawing 1 and which generates the image to which the water mark was given is built into various products in various different scenarios with which this invention is applied. For example, a coded-image processor can be connected to a website or a web server, and the image to which the water mark was given can be downloaded. Before downloading the copy of an image, the codeword of a proper is introduced into the image to download and the codeword of this proper can detect the addressee of the downloaded image behind.

[0027]

In other examples of application, a coded-image processor is incorporated as some digital projectors (digital cinema projector), and in a movie theater, in case a discernment codeword projects a movie, it is added to an image. By this discernment codeword, the projector and movie theater which the movie projected can be pinpointed. Therefore, the projector and movie theater where the pirate edition copy was created can be pinpointed by the discernment codeword contained in the pirate edition copy which photoed the image projected from the projector and was obtained. On the other hand, the image to which the water mark was given may be copied as a photograph or printed matter, and may create and distribute the copy of the copied photograph or printed matter. In drawing 1 , the distribution place of the image to which the water mark generated by the coded-image processor was given is shown by the distribution 19 expressed by the cloud-shaped frame.

[0028]

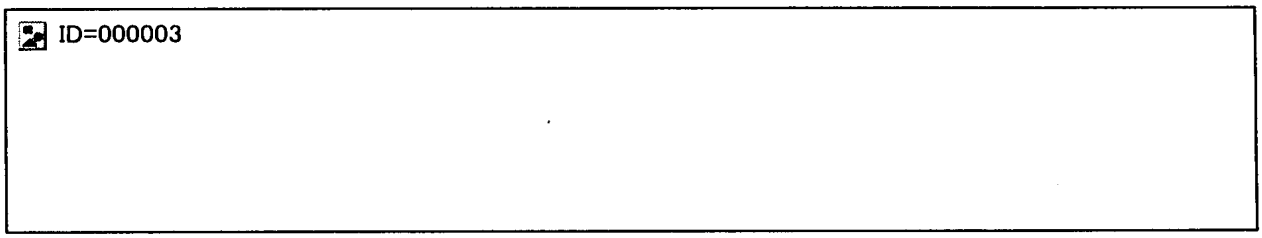
Detection processor

Drawing 2 is the block diagram showing the configuration of the detection image processing system (detecting image processing apparatus) which detects one or more codewords currently embedded in the OFENDINGU image (offending markedimage) to which the water mark was given. Speaking comprehensively, the detection image processing system shown in drawing 2 having the function to identify one or more codewords which exist in OFENDINGU of an image, i.e., a copy.

[0029]

OFENDINGU version W' of the image to which the water mark was given is supplied from the source of data, and is saved at a frame memory 20. Since the detection processing in this detection image processing system needs the original version of an image, the original version of an image is saved at the frame memory 24. The

original version of OFENDINGU version W' of the image to which the water mark was given, and an image is supplied to the registration processor (registration processor) 30 through the connection channels 26 and 28 according to individual, respectively.
[0030]
As mentioned above, OFENDINGU version W' of an image may have been generated by photoing or copying some images Wi to which the water mark was given. Then, in order to raise the detection ratio of a discernment codeword, the registration processor 30 arranges substantially the original version of the OFENDINGU image saved at frame memories 20 and 24, respectively, and an image (align). This purpose is investigating correspondence relation with the sample of the corresponding image Wi with which Sample I and the water mark of an original image are attached, and the codeword multiplier's is added.
[0031]
This registration processing is explained using drawing 3 . Drawing 3 compares OFENDINGU version W' of the original image I and the image to which the water mark was given, and is shown. As shown in drawing 3 , OFENDINGU version W' of the image to which the water mark was given has offset to the original image, and this offset may originate in the relative visual field of a camera that the OFENDINGU version of the image to which the water mark was given was generated.
[0032]
In order to reproduce the expression of a codeword multiplier, it is necessary to subtract the right sample of an original image from OFENDINGU version W' of the image to which the water mark was given. Two images are arranged for this processing. As shown in drawing 3 , registered image W″ has the boundary region (peripheral area) PA which contains in an original image the part not existing.
[0033]
By other examples, when an OFENDINGU version downloads, for example from the Internet, correspondence relation with the version I of an original image may already be in **, and, in such a case, it is not necessary to use the registration processor 30 with OFENDINGU image W'. Then, this detection image processing system is equipped with the alternative-channel 32 for supplying directly the image to which the water mark was given to the playback processor 40.
[0034]
Registered image W″ is supplied to the playback processor 40. The copy of the original image I is also supplied to the playback processor 40 through the 2nd channel 44. Image W″ and the original image I which were registered are changed into a DCT field by the DCT processor 46. Next, as shown in the following formulas, presumed codeword X' is computed by subtracting sample V' of the DCT field of the image to which the water mark was given from the sample V of the DCT field of an original image.



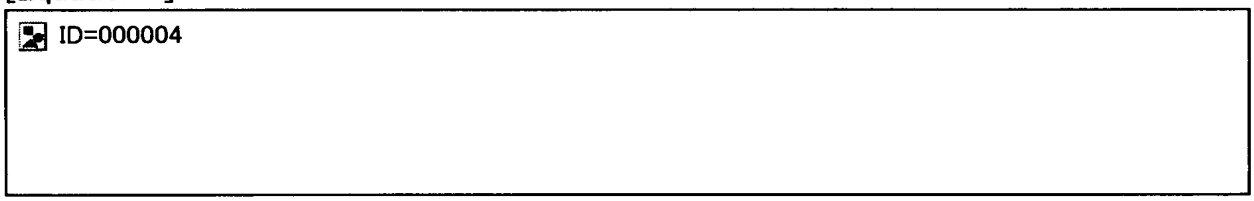
Therefore, the playback processor 40 outputs the estimate of the multiplier of the codeword which should be identified through the connection channel 50. Reproduced codeword X' is supplied to the 1st input terminal of correlator 52. The codeword Xi generated with the codeword generation vessel 54 is supplied to the 2nd input terminal of correlator 52. The codeword generation machine 54 generates the group of all possible codewords using the predetermined seed value which identifies to a proper the codeword read from memory 58 like the above-mentioned discernment codeword generation machine 8.

[0035]

Correlator 52 generates the similar value sim of n pieces (i). In one example, the similar value sim (i) is computed by searching for the correlation based on the following formulas.

[0036]

[Equation 1]



[0037]

Each of the similar value sim of n pieces (i) is supplied to a detector 60. and a detector 60 analyzes the similar value sim of n possible codewords (i) which is alike, respectively and receives. The relation between the example of the similar value sim (i) generated by correlator 52 and the threshold TH of each possible codeword is shown in drawing 4 . As shown in drawing 4 , two codewords 2001 and 12345 are over the threshold TH. For this reason, a detector 60 judges with the OFENDINGU image having been created from the version of the image to which the water mark corresponding to a codeword 2001 and a codeword 12345 was given. Therefore, in this example, the height of the threshold TH which guarantees incorrect detection probability can be set up based on the incorrect detection probability (false positive

probability) determined with the magnitude of the population which is 10 million, and water mark reinforcement (watermarking strength). By the example shown in drawing 4 , when the similar value generated by correlator 52 is over the threshold, it has this incorrect detection probability, the addressee of the image to which this water mark was given performs a malfeasance, and it is judged that it participated in creation of the OFENDINGU version Wi of the image to which the water mark was given.

[0038]

Hereafter, the water mark system feature and advantage which are shown in drawing 1 and drawing 2 are explained.

[0039]

Registration

The processing which arranges the OFENDINGU version of the image to which the water mark was given, and the copy of an original image includes the processing which investigates correlation with the sample of an original image, and the sample of the image to which the water mark was given. This correlation processing is performed by shifting each sample of an image by different shift amount. This processing is explained using drawing 5 . Drawing 5 A shows the discrete sample of an original image, and drawing 5 B shows the discrete sample of OFENDINGU image W' to which the water mark was given. As shown in drawing 5 A and drawing 5 B, the time difference between each sample is dt which becomes settled with a sampling rate. The group of each sample of these images is shifted and the result of having made the discrete sample correlating is shown in drawing 5 C.

[0040]

As shown in drawing 5 C, in the shift between the 6th sample and the 7th sample, the correlation peak is the highest. In addition, as the continuous curve CL which connects between samples shows, one between the 6th sample and the 7th sample has the actual peak shift between the original image I and OFENDINGU image W' to which the water mark was given.

[0041]

In a desirable example, the registration processor 30 detects the 2nd more precise location to this 1st registration location after detection of the 1st registration location. For this purpose, the registration processor 30 performs actuation as shown in drawing 6 . Drawing 6 A and drawing 6 B show the original image I and OFENDINGU image W' to which the water mark was given, and the exaggerated sampling of these images is carried out with the twice as many sampling rate as this. Therefore, the time difference between continuous samples is dt/2. The peak value of correlation between the exaggerated sampling versions of OFENDINGU image W' to which the original image I and the water mark were given is in the location of the 12th sample, and this location is carrying out **** correspondence in the location of the peak of a correlation output value so that drawing 6 C may show. Thus, the registration processor 30 can perform [rather than] precise registration to two

images by performing 2nd registration processing to the exaggerated sampling version of OFENDINGU image W' to which the original image I and the water mark were given.

[0042]

The further advantage using the registration processor 30 shown in drawing 2 is explained using drawing 7 . Drawing 7 is drawing showing registered-image W" created by the processing explained with reference to drawing 3 as compared with an original image. OFENDINGU image W" to which the water mark was given -- in order to raise the probability for an inner codeword to be detectable, the part not existing is permuted by the original image in the image to which the water mark was given shown as a boundary region PA by the field where an original image corresponds. the difference between the samples of the OFENDINGU image to which, as for this processing, the water mark was given with the sample of an original image -- when the absolute value sum is compared and this value is over the predetermined threshold, it is carried out by transposing the sample of an OFENDINGU image to the sample to which an original image corresponds simply. Thereby, the detection processing which correlator 52 and a detector 60 collaborate and perform improves remarkably. When the boundary region PA of the image with which the water mark not existing was temporarily given to the original image is used for playback of a codeword multiplier, these multipliers do not have a correlation in the version by which the codeword was reproduced. These multipliers will generate a big value and will become a serious noise in the similar value sim (i) which is total of a correlation value. For this reason, in a detector 60, the codeword exceeding a threshold TH is detected and the probability that a right codeword can be specified falls. On the other hand, the part of an OFENDINGU image is permuted by the part to which an original image corresponds as mentioned above, and things can perform lowering a overlooking probability (false negative probability) by setting a corresponding correlation term as zero effectively.

[0043]

Codeword generation

By generating the seed value of the random number used in order to generate a codeword from a source image sample, the engine performance of the example of this invention shown in drawing 1 and drawing 2 can be raised further. This processing analyzes the DCT multiplier of the image which should attach a water mark, and is realized by generating the seed value used from these DCT multipliers in order to generate a codeword. The "secure hash algorithm 1 (secure hashing algorithm 1:sha-1)" of the common knowledge for for example, this contractor can be used for this processing. This algorithm is specified to ANSI Standaards (ANSIx 9.30-2). This algorithm is indicated by A Jay Menezes (A. J.Menezes) work "an application cryptography handbook (Handbook of applied cryptography)." Thereby, a coded-image processor and a detection image processing system can generate and judge the seed value of a random number from a DCT multiplier.

[0044]
Other examples of application
In addition to the projector and web server which were mentioned above, the coded data processor of a water mark system is applicable to other applications. For example, this invention can receive a signal from a communication device, and can apply it also to the receiver/decoder which gives a water mark to information by introducing a codeword into this received signal. For example, a set top box receives television and a video signal from the "head end" device or multicast device of broadcast. In such an example of application, a coded data processor constitutes a part of set top box, and in case it receives and decodes a signal, it introduces a water mark codeword into a video signal. Setting in one example, this water mark codeword specifies the set top box which received and decoded the video signal as a proper.
[0045]
Furthermore, this invention is applicable also to the digital cinema receiver which receives digital cinema data (digital cinema film) from a satellite. This digital cinema receiver receives the signal showing a digital cinema, decodes this signal, and reproduces a digital cinema. This receiver is equipped with the coded data processor which introduces a water mark codeword into the decoded movie signal. A water mark codeword specifies the digital cinema receiver which received for example, digital cinema data as a proper.
[0046]
Furthermore, this invention is applicable to a digital camera or a camcorder equipped with memory and a memory controller etc. In this example of application, the coded data processor concerning this invention introduces the water mark codeword memorized by memory into the video signal photoed with the digital camera etc. In this example of application, the codeword is beforehand memorized by memory, therefore the coded data processor is not equipped with the codeword generation machine. The codeword memorized by memory is embedded under control of a memory controller at a video signal, and, thereby, specifies a video signal as a false proper target (quasi-uniquely) peculiar.
[0047]
In the further example, the coded data processor based on this invention embeds a series of water mark codewords according to an individual at each of the frame of the digital image from which the plurality which constitutes a continuous image or a continuous animation differs. These codewords may have relevance mutually and can identify now the image corresponding to each frame according to an individual by these codewords.
[0048]
The further various side faces and descriptions of this invention are defined in the attached claim. The gestalt of operation mentioned above can be changed variously, without deviating from this claim.

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of a coded-image processor.
[Drawing 2] It is the block diagram showing the configuration of a detection image processing system.
[Drawing 3] Drawing 3 A shows an original image, drawing 3 B shows the image to which the water mark was given, and drawing 3 C is drawing showing the registered image.
[Drawing 4] It is the graphical representation showing the example of the correlation result about each codeword of the group of the codeword of N individual.
[Drawing 5] Drawing 5 A is a graphical representation corresponding to the sample of the original image I, drawing 5 B is a graphical representation corresponding to image W' to which the water mark was given, and drawing 5 C is the graphical representation showing the correlation result for every discrete sample shift of an original image and the image to which the water mark was given.
[Drawing 6] Drawing 6 A is a graphical representation corresponding to the version by which the exaggerated sampling of the original image I was carried out, drawing 6 B is a graphical representation corresponding to the version by which the exaggerated sampling of image W' to which the water mark was given was carried out, and drawing 6 C is the graphical representation showing the correlation result for every discrete sample shift of the original image by which the exaggerated sampling was carried out, and the image to which the water mark was given.
[Drawing 7] It is drawing explaining pretreatment of the registered image which permutes the part which does not exist in the original image in the image to which the water mark was given by the part to which an original image corresponds.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of a coded-image processor.
[Drawing 2] It is the block diagram showing the configuration of a detection image processing system.
[Drawing 3] Drawing 3 A shows an original image, drawing 3 B shows the image to which the water mark was given, and drawing 3 C is drawing showing the registered image.
[Drawing 4] It is the graphical representation showing the example of the correlation result about each codeword of the group of the codeword of N individual.
[Drawing 5] Drawing 5 A is a graphical representation corresponding to the sample

of the original image I, drawing 5 B is a graphical representation corresponding to image W' to which the water mark was given, and drawing 5 C is the graphical representation showing the correlation result for every discrete sample shift of an original image and the image to which the water mark was given.
[Drawing 6] Drawing 6 A is a graphical representation corresponding to the version by which the exaggerated sampling of the original image I was carried out, drawing 6 B is a graphical representation corresponding to the version by which the exaggerated sampling of image W' to which the water mark was given was carried out, and drawing 6 C is the graphical representation showing the correlation result for every discrete sample shift of the original image by which the exaggerated sampling was carried out, and the image to which the water mark was given.
[Drawing 7] It is drawing explaining pretreatment of the registered image which permutes the part which does not exist in the original image in the image to which the water mark was given by the part to which an original image corresponds.

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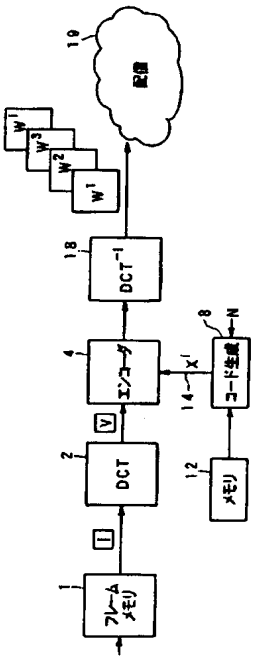
最終頁に続く

(54)【発明の名称】データ処理装置

(57)【要約】　（修正有）
【課題】ウォータマークが付されているマテリアルアイテムを高い確率で特定でき、見逃し確率を下げる。
【解決手段】オリジナルマテリアルアイテムのコピーに所定のコードワードの組のうちの１つのコードワードを導入し、オリジナルマテリアルアイテムのウオータマークが付されたバージョンを生成する。コードワードは、シード値により初期化される疑似乱数生成器により生成される。シード値は、このシード値により生成されたコードワードから、ウオータマークが付されたマテリアルアイテムを特定するために使用される。ウォータマークが付されたマテリアルアイテムからコードワードを再生し、コードワードの組内の全てのコードワードと再生されたコードワードとを相関させ、ウォータマークが付されたマテリアルアイテムの特定のコピーを検出する。
【選択図】　図１



【特許請求の範囲】
【請求項１】
オリジナルマテリアルの各サンプルに、それぞれ対応する各コードワード係数を結合することにより生成された、オリジナルマテリアルアイテムのウォータマークが付されたバージョン内に存在する１つ以上の所定のコードワードの組を識別する検出データ処理装置において、
上記オリジナルマテリアルアイテムのウォータマークが付されたバージョンのサンプルを、上記対応するコードワード係数が結合されたオリジナルマテリアルアイテムの対応するサンプルに関連付ける登録プロセッサと、
上記オリジナルマテリアルアイテムのサンプルと、上記ウォータマークが付されたバージョンの対応するサンプルとを比較することにより、コードワードを再生し、再生コードワードを生成する再生プロセッサと、
上記所定のコードワードの組における各コードワードについて、上記再生コードワードと生成されたコードワードとを相関させることにより相関値を生成する相関プロセッサと、
所定の閾値を超えるコードワードの相関値に基づいて、１つ以上のコードワードを検出する検出プロセッサとを備える検出データ処理装置。
【請求項２】
上記登録プロセッサは、
上記オリジナルマテリアルアイテムのサンプルと上記ウォータマークが付されたバージョンのサンプルについて、該オリジナルマテリアルアイテムのサンプルの該ウォータマークが付されたバージョンに対する各シフト毎に相関値を算出し、
上記各シフトのうち、最も高い相関値を示すシフトから上記オリジナルマテリアルアイテムにおける、上記ウォータマークが付されたバージョンに対する第１の登録位置を判定し、
上記オリジナルマテリアルアイテム及び上記ウォータマークが付されたバージョンをオーバサンプリングし、
上記オリジナルマテリアルアイテムのサンプルと上記ウォータマークが付されたバージョンのオーバサンプリングされたバージョンについて、上記第１の登録位置に対する各シフト毎に相関値を算出し、
上記オーバサンプリングされたバージョンの各シフトのうち、最も高い相関値を示すシフトから第２の登録位置を判定することを特徴とする請求項１記載の検出データ処理装置。
【請求項３】
上記登録プロセッサは、
上記第２の登録位置について、上記オリジナルマテリアルアイテムの各サンプルと上記ウォータマークが付されたバージョンの対応する各サンプルとの間の差分を算出し、
上記差分を所定の閾値と比較して、該差分が該閾値を超えているとき、該登録されたウォータマークが付されたバージョンのサンプルを上記オリジナルマテリアルアイテムの対応するサンプルに置換することを特徴とする請求項１又は２記載の検出データ処理装置。
【請求項４】
上記相関プロセッサは、再生コードワード係数を生成するための疑似乱数を生成するコードワード生成器を備え、該疑似乱数は、上記ウォータマークが付されたバージョンのサンプルに基づいて生成されるシード値から生成されることを特徴とする請求項１乃至３いずれか１項記載の検出データ処理装置。
【請求項５】
上記コードワードは、離散コサイン変換領域においてマテリアルアイテムに導入され、当該検出データ処理装置は、
上記ウォータマークが付されたバージョンとオリジナルマテリアルアイテムとを離散コサイン変換領域に変換する離散コサイン変換プロセッサを備え、上記再生プロセッサは、上記オリジナルマテリアルアイテムの離散コサイン変換係数から、上記ウォータマークが付されたバージョンの対応する離散コサイン変換係数を減算することにより、上記再生コー

ドワードを生成することを特徴とする請求項１乃至４いずれか１項記載の検出データ処理装置。

【請求項６】

オリジナルマテリアルアイテムのコピーに所定のコードワードの組のうちの１つのコードワードを導入することにより、該オリジナルマテリアルアイテムの少なくとも１つのウォータマークが付されたバージョンを生成する符号化データ処理装置において、

上記コードワードの所定の組から複数のコードワード係数を有するコードワードを生成するコードワード生成器と、

上記オリジナルマテリアルアイテムの対応する複数のサンプルに上記各コードワード係数を結合し、上記ウォータマークが付されたバージョンを生成する符号化プロセッサとを備え、

上記コードワードは、該コードワードに固有に関連付けられているシード値によって初期化される疑似乱数生成器を用いて生成され、上記コードワード係数は、該疑似乱数生成器によって生成された数値から生成されることを特徴とする符号化データ処理装置。

【請求項７】

上記コードワード生成器は、上記マテリアルアイテムのサンプルから上記シード値を生成することを特徴とする請求項６記載の符号化データ処理装置。

【請求項８】

上記マテリアルアイテムを離散コサイン変換領域に変換する離散コサイン変換プロセッサと、

上記離散コサイン変換領域のマテリアルアイテムは、複数の離散コサイン係数によって表現され、上記符号化プロセッサは、上記コードワード係数と対応する離散コサイン変換係数の１つとを加算することにより、上記コードワード係数と上記マテリアルアイテムとを結合し、該符号化プロセッサによって上記コードワードが加算された上記離散コサイン変換された画像を逆離散コサイン変換することにより、上記マテリアルアイテムのウォータマークが付されたバージョンを生成する逆離散コサイン変換プロセッサとを備える請求項６又は７記載の符号化データ処理装置。

【請求項９】

オーディオ信号及び画像信号のうちの少なくとも１つが供給され、複写処理の前に該オーディオ信号及び画像信号のうちの少なくとも１つにコードワードを導入する請求項６乃至８いずれか１項記載の符号化データ処理装置を備える映写装置。

【請求項１０】

インターネットを介してダウンロードされるマテリアルアイテムを提供するウェブサーバであって、該マテリアルアイテムがダウンロードされる前に該マテリアルアイテムが供給され、該マテリアルアイテムにコードワードを導入する請求項６乃至８いずれか１項記載の符号化データ処理装置を備えるウェブサーバ。

【請求項１１】

マテリアルアイテムの受信者を特定する受信者特定システムにおいて、

上記受信者を固有に特定するシード値から生成されたコードワードをマテリアルアイテムに導入することにより、ウォータマークが付されたマテリアルアイテムを生成する請求項６乃至８いずれか１項記載の符号化データ処理装置と、

上記マテリアルアイテムにおけるコードワードの有無を検出することにより、所定の誤検出確率で該マテリアルアイテムの受信者を検出する請求項１乃至６いずれか１項記載の検出データ処理装置とを備える受信者特定システム。

【請求項１２】

オリジナルマテリアルの各サンプルに、それぞれ対応する各コードワード係数を結合することにより生成された、オリジナルマテリアルアイテムのウォータマークが付されたバージョン内に存在する１つ以上の所定のコードワードの組を識別する識別方法において、

上記オリジナルマテリアルアイテムのウォータマークが付されたバージョンのサンプルを、上記対応するコードワード係数が結合されたオリジナルマテリアルアイテムの対応する

サンプルに関連付けるステップと、
上記オリジナルマテリアルアイテムのサンプルと、上記ウォータマークが付されたバージョンの対応するサンプルとを比較することにより、コードワードを再生し、再生コードワードを生成するステップと、
上記所定のコードワードの組における各コードワードについて、上記再生コードワードと生成されたコードワードとを相関させることにより相関値を生成するステップと、
所定の閾値を超えるコードワードの相関値に基づいて、１つ以上のコードワードを検出するステップとを有する識別方法。
【請求項１３】
オリジナルマテリアルアイテムのコピーに所定のコードワードの組のうちの１つのコードワードを導入することにより、該オリジナルマテリアルアイテムの少なくとも１つのウォータマークが付されたバージョンを生成するウォータマーク付加方法において、
上記コードワードの所定の組から複数のコードワード係数を有するコードワードを生成するステップと、
上記オリジナルマテリアルアイテムの対応する複数のサンプルに上記各コードワード係数を結合し、上記ウォータマークが付されたバージョンを生成するステップとを有し、
上記コードワードを生成するステップは、
上記コードワードに固有に関連付けられているシード値によって疑似乱数生成器を初期化するステップと、
上記疑似乱数生成器によって生成された数値から上記コードワード係数を生成するステップとを有することを特徴とするウォータマーク付加方法。
【請求項１４】
請求項６乃至８いずれか１項記載の符号化データ処理装置によってコードワードが付加されたマテリアルアイテムを表すデータ信号。
【請求項１５】
請求項１４記載のデータ信号が記録されたデータ媒体。
【請求項１６】
データプロセッサにロードされて、該データプロセッサを請求項１乃至５いずれか１項記載の検出データ処理装置又は請求項６乃至８いずれか１項記載の符号化データ処理装置として動作させるコンピュータにより実行可能な命令を提供するコンピュータプログラム。
【請求項１７】
データプロセッサにロードされて、該データプロセッサに請求項１２又は１３記載の方法を実行させるコンピュータにより実行可能な命令を提供するコンピュータプログラム。
【請求項１８】
請求項１６又は１７記載のコンピュータプログラムを表す情報信号が記録されているコンピュータにより読取可能な媒体を備えるコンピュータプログラム製品。
【請求項１９】
マテリアルアイテムを表す信号を受信する受信装置であって、請求項６乃至８いずれか１項記載の符号化データ処理装置を備え、受信信号を固有に識別する少なくとも１つのコードワードを該受信信号に結合する受信装置。
【請求項２０】
添付の図面を参照して以下に説明する検出データ処理装置又は符号化データ処理装置。
【請求項２１】
添付の図面を参照して以下に説明する識別方法又はウォータマーク付加方法。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】
本発明は、マテリアルアイテムのバージョンにコードワード（ｃｏｄｅ　ｗｏｒｄｓ）を埋め込む符号化データ処理装置及び方法に関する。幾つかの用途においては、コードワードは、マテリアルアイテムを識別するために使用される。これに対応して、本発明は、マ

テリアルアイテムに埋め込まれた１つ以上のコードワードを検出するデータ処理装置及び方法に関する。

【０００２】

【従来の技術】

マテリアルを識別するために、マテリアルに情報を埋め込む処理は、ウォータマーキング処理と呼ばれる。

【０００３】

識別コードワードは、マテリアルアイテムのバージョンを識別するために、マテリアルアイテムのバージョンに埋め込まれる。すなわち、ウォータマーキング処理により、マテリアルの特定のバージョンの受信者を特定することができる。ここで、マテリアルの配信者の意向にそぐわない形でマテリアルがコピー又は使用された場合、配信者は、識別コードワードからマテリアルのバージョンを特定し、適切な対策を講ずることができる。

【０００４】

この明細書においては、マテリアルの供給者、所有者、作成者又は配信者の意向にそぐわない形でコピー又は使用されたマテリアルアイテムを、便宜的にマテリアルのオフェンディングアイテム（ｏｆｆｅｎｄｉｎｇ　ｉｔｅｍ）又はオフェンディングマテリアル（ｏｆｆｅｎｄｉｎｇ　ｍａｔｅｒｉａｌ）と呼ぶ。

【０００５】

マテリアルは、ビデオマテリアル、オーディオマテリアル、オーディオ／ビデオマテリアル、ソフトウェアプログラム、デジタル文書及びいかなる種類の情報を含むマテリアル（ｉｎｆｏｒｍａｔｉｏｎ　ｂｅａｒｉｎｇ　ｍａｔｅｒｉａｌ）のいずれであってもよい。

【０００６】

ウォータマークの仕組みを成功させるためには、ユーザが識別コードを除去することが可能な限り困難である必要がある。また、ユーザが識別コードを変更し、マテリアルのオフェンディングアイテムの作成者を他人にみせかけることも可能な限り困難である必要がある。このようなユーザによるコードワードのマスク又はコードワードが他のユーザを示すようにするような改竄は、コルージョンアタック（ｃｏｌｌｕｓｉｏｎ　ａｔｔａｃｋ）と呼ばれる。

【０００７】

【発明が解決しようとする課題】

全てのウォータマークの仕組みにおいて、同じマテリアルのコピーを受け取ったユーザがコルージョンアタックに成功することが困難となるようにする必要がある。したがって、ウォータマークの仕組みは、コルージョンアタックの対象となったウォータマークが付されているマテリアルアイテムを高い確率で特定できるものである必要がある。この特定は、オフェンディングマテリアルから再生されたコードワードを識別することにより実現される。一方、コードワードが存在するのにコードワードが存在しないと判定してしまう確率（見逃し確率：ｆａｌｓｅ　ｎｅｇａｔｉｖｅ　ｐｒｏｂａｂｉｌｉｔｙ）は、低くなくてはならない。更に、実際にはコルージョンアタックに加担していないユーザを誤って不正行為を行ったユーザであると判定してしまう確率（誤検出確率：ｆａｌｓｅ　ｐｏｓｉｔｉｖｅ　ｐｒｏｂａｂｉｌｉｔｙ）は、可能な限り低くしなくてはならない。

【０００８】

米国特許第５６６４０１８号は、マテリアルから複数のコピーに所定数の係数を有するコードワードから作成されたデジタルウォータマークを付すウォータマーキング処理を開示している。ウォータマークが付されるマテリアルアイテムは、例えば画像である。ここで開示されているウォータマークの埋込を行う装置は、画像を離散コサイン変換（Ｄｉｓｃｒｅｔｅ　Ｃｏｓｉｎｅ　Ｔｒａｎｓｆｏｒｍ：以下、ＤＣＴという。）領域に変換する。デジタルウォータマークは、正規分布を有し、ランダムに分布した係数の組から構成されている。ＤＣＴ領域において、それぞれ各ＤＣＴ係数に対応する各コードワード係数が付加される。これに関連する文献である１９９８年７月２７日、ＭＩＴから発行された、

ジェイ・キリアン（Ｊ．Ｋｉｌｉａｎ）、エフ・ティー・レイトン（Ｆ．Ｔ．Ｌｅｉｇｈｔｏｎ）著、「コルージョンアタックに対するデジタルウォータマークの保護（Ｒｅｓｉｓｔａｎｃｅ　ｏｆ　Ｄｉｇｉｔａｌ　Ｗａｔｅｒｍａｒｋｓ　ｔｏ　Ｃｏｌｌｕｓｉｏｎ　Ａｔｔａｃｋｓ）」には、アタックを防ぐためのこのウォータマーキング処理の詳細な数学的解析が開示されている。

【０００９】

【課題を解決するための手段】

本発明の第１の側面として、本発明は、オリジナルマテリアルアイテムのウォータマークが付されたバージョン内に存在する１つ以上の所定のコードワードの組を識別する検出データ処理装置を提供する。ウォータマークが付されたバージョンは、オリジナルマテリアルの複数の各サンプルに、それぞれ対応する各コードワード係数を結合することにより生成される。検出データ処理装置は、オリジナルマテリアルアイテムのウォータマークが付されたバージョンのサンプルを、対応するコードワード係数が結合されたオリジナルマテリアルアイテムの対応するサンプルに関連付ける登録プロセッサを備える。検出データ処理装置は、更に、オリジナルマテリアルアイテムのサンプルと、ウォータマークが付されたバージョンの対応するサンプルとを比較することにより、コードワードを再生し、再生コードワードを生成する再生プロセッサと、所定のコードワードの組における各コードワードについて、再生コードワードと生成されたコードワードとを相関させることにより相関値を生成する相関プロセッサと、所定の閾値を超えるコードワードの相関値に基づいて、１つ以上のコードワードを検出する検出プロセッサとを備える。

【００１０】

本発明の第２の側面として、本発明は、オリジナルマテリアルアイテムのコピーに所定のコードワードの組のうちの１つのコードワードを導入することにより、オリジナルマテリアルアイテムの少なくとも１つのウォータマークが付されたバージョンを生成する符号化データ処理装置を提供する。符号化データ処理装置は、コードワードの所定の組から複数のコードワード係数を有するコードワードを生成するコードワード生成器を備える。更に、符号化データ処理装置は、オリジナルマテリアルアイテムの対応する複数のサンプルに各コードワード係数を結合し、ウォータマークが付されたバージョンを生成する符号化プロセッサを備える。コードワード生成器は、疑似乱数生成器を備える。コードワード生成器は、コードワードに固有に関連付けられているシード値によって疑似乱数生成器を初期化し、疑似乱数生成器によって生成された数値からコードワードを生成する。

【００１１】

本発明は、米国特許第５６６４０１８号に開示されているような、ランダムに分布した係数を有するコードワードを利用した現実的なウォータマークシステムを提供することを目的とする。本発明では、検出データ処理装置及び符号化データ処理装置の一部を構成する疑似乱数生成器を用いる。疑似乱数生成器はシード値を用い、シード値は、疑似乱数生成器が生成する数値のシーケンスを決定する。シード値は、このシード値から生成されたコードワードが埋め込まれたウォータマークが付されたマテリアルアイテムのバージョンに固有に関連付けられている。したがって、このシード値により、ウォータマークが付されたマテリアルアイテムのバージョンを容易に特定することができる。

【００１２】

本発明に基づく検出データ処理装置は、登録プロセッサを備える。登録プロセッサにより、検出データ処理装置の性能が更に高くなる。マテリアルアイテムのウォータマークが付されたバージョンをマテリアルアイテムのオリジナルコピーに対応させて登録することにより、コードワードの存在を検出できる確率が高くなり、見逃し確率（ｆａｌｓｅ　ｎｅｇａｔｉｖｅ　ｐｒｏｂａｂｉｌｉｔｙ）を下げることができる。これは、ウォータマークが付されたマテリアルアイテムのサンプルは、オリジナルマテリアルアイテムのサンプルに対応する可能性が高いため、コードワードを再生できる確率が高くなるからである。

【００１３】

本発明の好ましい具体例においては、コードワードのシード値は、オリジナルマテリアル

アイテムのサンプルの値から導出される。これにより、各コードワードに対するシード値を、符号化データ処理装置と検出データ処理装置との間で送受する必要がなくなる。

【００１４】

本発明の更なる側面及び特徴は、添付の請求の範囲において定義されている。

【００１５】

【発明の実施の形態】

ウォータマークシステムの概観

以下、本発明の実施の形態をビデオ画像の保護に関連させて説明する。ビデオ画像を配信すべきユーザの数によりコピーの数が決定する。各コピーには、これらのユーザのうちの１人に割り当てられたコピーを識別するための識別コードワード（ｉｄｅｎｔｉｆｉｃａｔｉｏｎ　ｃｏｄｅ　ｗｏｒｄ）が付加される。

【００１６】

ビデオ画像は、デジタルコードワードを埋め込むことにより保護されるマテリアルの一具体例である。コードワードを埋め込むことにより保護されるマテリアルは、ビデオ画像の他に、ソフトウェアプログラム、デジタル文書、音楽、オーディオ信号及び他のいかなる種類の情報を含むマテリアルであってもよい。

【００１７】

図１は、オリジナル画像のコピーに識別コードワードを導入する符号化画像処理装置（ｅｎｃｏｄｉｎｇ　ｉｍａｇｅ　ｐｒｏｃｅｓｓｉｎｇ　ａｐｐａｒａｔｕｓ）の具体的構成を示すブロック図である。オリジナル画像Ｉは、ソースから供給され、フレームメモリ１に保存される。このオリジナル画像は、ウォータマークが付された複数のコピーとして複写される（ｒｅｐｒｏｄｕｃｅ）ものであり、各コピーには、固有の識別コードワードが付される。オリジナル画像は、ＤＣＴプロセッサ２に供給され、ＤＣＴプロセッサ２は、オリジナル画像を８×８の画素ブロックに分割し、８×８の各画素ブロックにＤＣＴ処理を施す。これにより、ＤＣＴプロセッサ２は、ＤＣＴ変換画像Ｖを生成する。

【００１８】

以下の説明において、「サンプル」という用語は、画像（又は、実際には他の種類のマテリアルであってもよい。）を構成する離散サンプルを指すものとする。サンプルは、画素からも複写することができる画像の輝度サンプルであってもよい。したがって、サンプルという用語と画素という用語は、状況によっては交換可能である場合もある。

【００１９】

ＤＣＴ画像Ｖは、符号化プロセッサ（以下、エンコーダともいう。）４に供給される。符号化プロセッサ４には、識別コードワード生成器８から識別コードワードも供給されている。

【００２０】

識別コードワード生成器８には、複数のシード値（ｓｅｅｄ）が供給される。各シード値は、それぞれ対応する識別コードワードの１つを生成するために使用される。生成された各識別コードワードは、オリジナル画像のコピーに埋め込まれ、これによりウォータマークが付された画像が生成される。識別コードワード生成器８は、疑似乱数生成器を備える。疑似乱数生成器は、特定の識別コードワードを形成するためのコードワード係数を生成する。好ましい具体例においては、コードワード係数は、正規分布に基づいて生成される。なお、これに代えて、コードワード係数は、疑似乱数生成器を初期化するために用いるシード値に基づいて、予め定めてもよい。したがって、各識別コードワードには、対応するシード値が存在し、各シード値は、メモリ１２に記憶されている。すなわち、識別コードワードX^1を生成するために、シード値$seed_1$をメモリ１２から読み出し、このシード値$seed_1$を用いて、識別コードワード生成器８内の疑似乱数生成器を初期化する。

【００２１】

以下の説明では、オリジナル画像のＤＣＴバージョンをＶと表す。ここで、

$V = \{v_1\} = \{v_1, v_2, v_3, v_4, \cdots, v_N\}$

であり、v_iは、画像のＤＣＴ係数である。他の具体例においては、v_iは、画像のサンプル値であり、空間領域における画像のサンプル値又は他の領域における画像のサンプル値を表すものであってもよい。

【００２２】

各識別コードワードX^iは、以下のように、ｎ個のコードワード係数から構成されている。

$X^i = \{x^i_j\} = \{x^i_1, x^i_2, x^i_3, x^i_4, \cdots, x^i_n\}$

コードワード係数の数ｎは、オリジナル画像Ｖのサンプル数に対応する。なお、係数の数は異なるものであってもよく、この数は、特定のアプリケーションに応じて決定してもよい。

【００２３】

そして、ｉ番目の識別コードワードX^iを構成するコードワード係数のベクトルは、チャンネル１４を介してエンコーダ４に供給される。エンコーダ４は、画像Ｖに識別コードワードX^iを付加することにより、ウォータマークが付された画像W_iを生成する。実際には、以下の式に示すように、画像の各係数に各コードワード係数を加えることにより、ウォータマークが付された画像W_iが生成される。

$W_i = V + X^i$

$W_i = v_1 + x^i_1, v_2 + x^i_2, v_3 + x^i_3, v_4 + x^i_4, \cdots, v_n + x^i_n$

図１に示すように、ウォータマークが付された画像W_iは、エンコーダ４により生成された画像を逆ＤＣＴ変換する逆ＤＣＴプロセッサ１８によって、逆ＤＣＴ変換された後、この画像処理装置から出力される。

【００２４】

したがって、図１に示すように、エンコーダ４からは、ウォータマークが付された画像の組が出力される。データワードを最大２０ビットとすると、一千万個の識別コードワードの１つを選択することができ、オリジナル画像に対して、一千万個のウォータマークが付されたバージョンW_iを生成することができる。

【００２５】

この識別コードワードにより、画像Ｉのウォータマークが付されたコピーW_iを個別に識別することができるが、他の具体例においては、上述の２０ビットにより、画像内でデータを送ることができる。したがって、以下に説明するように、識別コードワードを選択するために使用される２０ビットは、画像Ｖ内でデータを送るための２０ビットのペイロードを提供する。

【００２６】

図１に示す、ウォータマークが付された画像を生成する符号化画像処理装置は、本発明が適用される様々な異なるシナリオにおいて、様々な製品に組み込まれる。例えば、符号化画像処理装置をウェブサイト又はウェブサーバに接続して、ウォータマークが付された画像をダウンロードすることができる。画像のコピーをダウンロードする前に、ダウンロードされる画像には固有のコードワードが導入され、この固有のコードワードにより、ダウンロードされた画像の受信者を後に検出することができる。

【００２７】

他の適用例では、符号化画像処理装置は、デジタル映写機（ｄｉｇｉｔａｌ　ｃｉｎｅｍａ　ｐｒｏｊｅｃｔｏｒ）の一部として組み込まれ、識別コードワードは、例えば映画館において、映画を映写する際に、映像に付加される。この識別コードワードにより、映画が映写された映写機及び映画館を特定することができる。したがって、映写機から映写された映像を撮影して得られた海賊版コピーに含まれる識別コードワードにより、その海賊版コピーが作成された映写機及び映画館を特定することができる。一方、ウォータマークが付された画像は、写真又は印刷物として複写されてもよく、複写された写真又は印刷物のコピーを作成及び配布してもよい。図１においては、符号化画像処理装置によって生成されるウォータマークが付された画像の配信先は、雲形の枠で表現された配信１９で示さ

れている。

【００２８】

検出プロセッサ

図２は、ウォータマークが付されたオフェンディング画像（ｏｆｆｅｎｄｉｎｇ ｍａｒｋｅｄｉｍａｇｅ）内に埋め込まれている１つ以上のコードワードを検出する検出画像処理装置（ｄｅｔｅｃｔｉｎｇ ｉｍａｇｅ ｐｒｏｃｅｓｓｉｎｇ ａｐｐａｒａｔｕｓ）の構成を示すブロック図である。包括的にいえば、図２に示す検出画像処理装置は、画像のオフェンディング、すなわちコピー内に存在する１つ以上のコードワードを識別する機能を有している。

【００２９】

ウォータマークが付された画像のオフェンディングバージョンW’は、データ源から供給され、フレームメモリ２０に保存される。この検出画像処理装置における検出処理は、画像のオリジナルバージョンを必要とするため、フレームメモリ２４には、画像のオリジナルバージョンが保存されている。ウォータマークが付された画像のオフェンディングバージョンW’及び画像のオリジナルバージョンは、それぞれ個別の接続チャンネル２６、２８を介して、登録プロセッサ（ｒｅｇｉｓｔｒａｔｉｏｎ ｐｒｏｃｅｓｓｏｒ）３０に供給される。

【００３０】

上述のように、画像のオフェンディングバージョンW’は、ウォータマークが付された画像W_Iの一部を撮影又は複写することにより生成された可能性がある。そこで、識別コードワードの検出率を高めるために、登録プロセッサ３０は、それぞれフレームメモリ２０、２４に保存されているオフェンディング画像と画像のオリジナルバージョンとを実質的に揃える（ａｌｉｇｎ）。この目的は、オリジナル画像のサンプルＩと、ウォータマークが付され、コードワード係数が付加されている対応する画像W_Iのサンプルとの対応関係を調べることである。

【００３１】

この登録処理を図３を用いて説明する。図３は、オリジナル画像Ｉとウォータマークが付された画像のオフェンディングバージョンW’とを比較して示している。図３に示すように、ウォータマークが付された画像のオフェンディングバージョンW’は、オリジナル画像に対してオフセットを有しており、このオフセットは、ウォータマークが付された画像のオフェンディングバージョンが生成されたカメラの相対的な視野に起因する可能性がある。

【００３２】

コードワード係数の表現を再生するために、ウォータマークが付された画像のオフェンディングバージョンW’からオリジナル画像の正しいサンプルを減算する必要がある。この処理のために、２つの画像が揃えられる。図３に示すように、登録された画像W”は、オリジナル画像には存在しない部分を含む周辺領域（ｐｅｒｉｐｈｅｒａｌ ａｒｅａ）ＰＡを有している。

【００３３】

他の具体例では、例えばインターネットからオフェンディングバージョンがダウンロードされた場合等、オフェンディング画像W’と既にオリジナル画像のバージョンＩとの対応関係が明かであることがあり、このような場合、登録プロセッサ３０を使用する必要はない。そこで、この検出画像処理装置は、ウォータマークが付された画像を再生プロセッサ４０に直接供給するための代替的なチャンネル３２を備えている。

【００３４】

登録された画像W”は、再生プロセッサ４０に供給される。再生プロセッサ４０には、第２のチャンネル４４を介して、オリジナル画像Ｉのコピーも供給される。登録された画像W”及びオリジナル画像Ｉは、ＤＣＴプロセッサ４６によって、ＤＣＴ領域に変換される。次に、以下の式に示すように、オリジナル画像のＤＣＴ領域のサンプルＶからウォータマークが付された画像のＤＣＴ領域のサンプルＶ’を減算することにより、推定コードワ

ードX'が算出される。

$$X' = V' - V$$
$$= v'_1 - v_1, v'_2 - v_2, v'_3 - v_3, v'_4 - v_4, \cdots, v'_n - v_n$$
$$= x'_1, x'_2, x'_3, x'_4, \cdots, x'_n$$

したがって、再生プロセッサ４０は、接続チャンネル５０を介して、識別すべきコードワードの係数の推定値を出力する。再生されたコードワードX'は、相関器５２の第１の入力端子に供給される。相関器５２の第２の入力端子には、コードワード生成器５４によって生成されたコードワードX^iが供給されている。コードワード生成器５４は、上述の識別コードワード生成器８と同様に、メモリ５８から読み出したコードワードを固有に識別する所定のシード値を用いて全ての可能なコードワードの組を生成する。

【００３５】

相関器５２は、ｎ個の類似値ｓｉｍ（ｉ）を生成する。一具体例においては、類似値ｓｉｍ（ｉ）は、以下の式に基づく相関を求めることにより算出される。

【００３６】

【数１】

$$sim(i)=\frac{X^i * X'}{\sqrt{X^i * X'}}=\frac{x^i_1 * x'_1+x^i_2 * x'_2+x^i_3 * x'_3+\ldots+x^i_n * x'_n}{\sqrt{x^i_1 * x'_1+x^i_2 * x'_2+x^i_3 * x'_3+\ldots+x^i_n * x'_n}}$$

【００３７】

ｎ個の類似値ｓｉｍ（ｉ）のそれぞれは、検出器６０に供給される。そして、検出器６０は、ｎ個の可能なコードワードのそれぞれに対する類似値ｓｉｍ（ｉ）を分析する。相関器５２によって生成される類似値ｓｉｍ（ｉ）の具体例と、可能な各コードワードの閾値ＴＨとの関係を図４に示す。図４に示すように、２つのコードワード２００１、１２３４５が閾値ＴＨを超えている。このため、検出器６０は、コードワード２００１及びコードワード１２３４５に対応するウォータマークが付された画像のバージョンからオフェンディング画像が作成されたと判定する。したがって、この具体例においては、一千万である母集団の大きさにより決定される誤検出確率（ｆａｌｓｅ　ｐｏｓｉｔｉｖｅ　ｐｒｏｂａｂｉｌｉｔｙ）と、ウォータマーク強度（ｗａｔｅｒｍａｒｋｉｎｇ　ｓｔｒｅｎｇｔｈ）とに基づいて、誤検出確率を保証する閾値ＴＨの高さを設定することができる。図４に示す具体例では、相関器５２によって生成された類似値が閾値を超えている場合、この誤検出確率をもって、このウォータマークが付された画像の受信者が不正行為を行い、ウォータマークが付された画像のオフェンディングバージョンW^iの作成に関与したと判断される。

【００３８】

以下、図１及び図２に示すウォータマークシステムの特徴及び利点を説明する。

【００３９】

登録

ウォータマークが付された画像のオフェンディングバージョンと、オリジナル画像のコピーとを揃える処理は、オリジナル画像のサンプルと、ウォータマークが付された画像のサンプルとの相関を調べる処理を含む。この相関処理は、画像の各サンプルを異なるシフト量でシフトさせて実行される。この処理を図５を用いて説明する。図５Ａは、オリジナル画像の離散サンプルを示し、図５Ｂは、ウォータマークが付されたオフェンディング画像W'の離散サンプルを示している。図５Ａ及び図５Ｂに示すように、各サンプル間の時間差は、サンプリングレートにより定まるｄｔである。これらの画像の各サンプルの組をシ

フトし、離散サンプルを相関させた結果を図５Ｃに示す。

【００４０】

図５Ｃに示すように、第６サンプルと第７サンプルの間のシフトにおいて、相関ピークが最も高くなっている。なお、サンプル間を結ぶ連続的な曲線ＣＬで示すように、オリジナル画像Ｉとウォータマークが付されたオフェンディング画像Ｗ’との間の実際のピークシフトは、第６サンプルと第７サンプルの間の一点にある。

【００４１】

好ましい具体例においては、登録プロセッサ３０は、第１の登録位置の検出の後、この第１の登録位置に対してより精密な第２の位置を検出する。この目的で、登録プロセッサ３０は、図６に示すような動作を行う。図６Ａ及び図６Ｂは、オリジナル画像Ｉとウォータマークが付されたオフェンディング画像Ｗ’とを示しており、これらの画像は、２倍のサンプリングレートでオーバサンプリングされている。したがって、連続するサンプル間の時間差は、ｄｔ／２である。図６Ｃから分かるように、オリジナル画像Ｉとウォータマークが付されたオフェンディング画像Ｗ’のオーバサンプリングバージョン間の相関のピーク値は、第１２サンプルの位置にあり、この位置は、相関出力値のピークの位置に略々対応している。このように、登録プロセッサ３０は、オリジナル画像Ｉとウォータマークが付されたオフェンディング画像Ｗ’のオーバサンプリングバージョンに対して第２の登録処理を実行することにより、２つの画像に対するより精密な登録を行うことができる。

【００４２】

図２に示す登録プロセッサ３０を用いる更なる利点について、図７を用いて説明する。図７は、図３を参照して説明した処理により作成された登録画像Ｗ”をオリジナル画像と比較して示す図である。ウォータマークが付されたオフェンディング画像Ｗ”内のコードワードを検出できる確率を高めるために、周辺領域ＰＡとして示されている、ウォータマークが付された画像におけるオリジナル画像には存在しない部分は、オリジナル画像の対応する領域によって置換される。この処理は、オリジナル画像のサンプルと、ウォータマークが付されたオフェンディング画像のサンプルとの間の差分絶対値和を比較し、この値が所定の閾値を超えているとき、オフェンディング画像のサンプルをオリジナル画像の対応するサンプルに単純に置き換えることにより行われる。これにより、相関器５２と検出器６０が協働して実行する検出処理が著しく向上する。仮に、オリジナル画像には存在しない、ウォータマークが付された画像の周辺領域ＰＡがコードワード係数の再生に使用された場合、これらの係数は、コードワードの再生されたバージョンに相関関係を有さない。これらの係数は大きな値を生成し、相関値の総和である類似値ｓｉｍ（ｉ）における重大な雑音となってしまう。このため、検出器６０において、閾値ＴＨを超えるコードワードを検出し、正しいコードワードを特定できる確率が低下する。一方、上述のように、オフェンディング画像の部分をオリジナル画像の対応する部分に置換し、対応する相関項を効果的にゼロに設定することにより、見逃し確率（ｆａｌｓｅ　ｎｅｇａｔｉｖｅ　ｐｒｏｂａｂｉｌｉｔｙ）を下げることがことができる。

【００４３】

コードワード生成

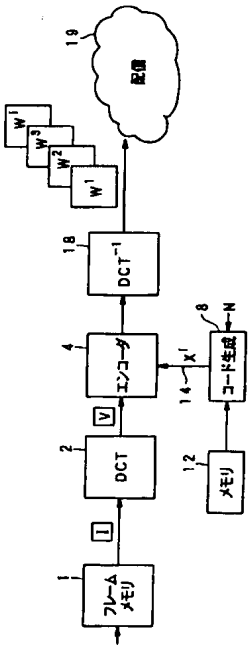
コードワードを生成するために使用される乱数のシード値をソース画像サンプルから生成することにより、図１及び図２に示す本発明の具体例の性能を更に高めることができる。この処理は、ウォータマークを付すべき画像のＤＣＴ係数を分析し、これらのＤＣＴ係数から、コードワードを生成するために使用するシード値を生成することにより実現される。この処理には、例えば、当業者にとって周知の「セキュアハッシュアルゴリズム１（ｓｅｃｕｒｅ　ｈａｓｈｉｎｇ　ａｌｇｏｒｉｔｈｍ　１：ｓｈａ－１）」を用いることができる。このアルゴリズムは、ＡＮＳＩ規格（ＡＮＳＩｘ９．３０－２）に規定されている。このアルゴリズムは、エー・ジェイ・メネゼス（Ａ．Ｊ．Ｍｅｎｅｚｅｓ）著「応用暗号学ハンドブック（Ｈａｎｄｂｏｏｋ　ｏｆ　ａｐｐｌｉｅｄ　ｃｒｙｐｔｏｇｒａｐｈｙ）」にも開示されている。これにより、符号化画像処理装置及び検出画像処理装置は、ＤＣＴ係数から乱数のシード値を生成及び判定することができる。

【００４４】
他の適用例
ウォータマークシステムの符号化データ処理装置は、上述した映写機及びウェブサーバに加えて、他の用途にも適用することができる。例えば、本発明は、通信装置から信号を受信し、この受信した信号にコードワードを導入することにより情報にウォータマークを付す受信機／デコーダにも適用することができる。例えば、セットトップボックスは、放送の「ヘッドエンド」機器又はマルチキャスト機器からテレビジョン及びビデオ信号を受信する。このような適用例では、符号化データ処理装置は、セットトップボックスの一部を構成し、信号を受信及びデコードする際にビデオ信号にウォータマークコードワードを導入する。一具体例においては、このウォータマークコードワードは、ビデオ信号を受信及びデコードしたセットトップボックスを固有に特定する。
【００４５】
更に、本発明は、衛星からデジタル映画データ（ｄｉｇｉｔａｌ　ｃｉｎｅｍａ　ｆｉｌｍ）を受信するデジタル映画受信機にも適用することができる。このデジタル映画受信機は、デジタル映画を表す信号を受信し、この信号をデコードしてデジタル映画を再生する。この受信機は、デコードされた映画信号にウォータマークコードワードを導入する符号化データ処理装置を備える。ウォータマークコードワードは、例えば、デジタル映画データを受信したデジタル映画受信機を固有に特定する。
【００４６】
更に、本発明は、メモリ及びメモリコントローラを備えるデジタルカメラ又はカムコーダ等にも適用することができる。この適用例では、本発明に係る符号化データ処理装置は、メモリに記憶されているウォータマークコードワードをデジタルカメラ等によって撮影されたビデオ信号に導入する。この適用例においては、コードワードは予めメモリに記憶されており、したがって、符号化データ処理装置は、コードワード生成器を備えていない。メモリに記憶されているコードワードは、メモリコントローラの制御の下、ビデオ信号に埋め込まれ、これによりビデオ信号を固有に又は疑似固有的（ｑｕａｓｉ－ｕｎｉｑｕｅｌｙ）に特定する。
【００４７】
更なる具体例においては、本発明に基づく符号化データ処理装置は、連続的な画像又は動画を構成する複数の異なるデジタル画像のフレームのそれぞれに一連のウォータマークコードワードを個別に埋め込む。これらのコードワードは、互いに関連性を有していてもよく、これらのコードワードにより、各フレームに対応する画像を個別に識別することができるようになる。
【００４８】
本発明の更なる様々な側面及び特徴は、添付の請求の範囲において定義されている。この請求の範囲から逸脱することなく、上述した実施の形態を様々に変更することができる。
【図面の簡単な説明】
【図１】符号化画像処理装置の構成を示すブロック図である。
【図２】検出画像処理装置の構成を示すブロック図である。
【図３】図３Ａはオリジナル画像を示し、図３Ｂはウォータマークが付された画像を示し、図３Ｃは登録された画像を示す図である。
【図４】Ｎ個のコードワードの組の各コードワードに関する相関結果の具体例を示すグラフ図である。
【図５】図５Ａはオリジナル画像Ｉのサンプルに対応するグラフ図であり、図５Ｂはウォータマークが付された画像Ｗ’に対応するグラフ図であり、図５Ｃはオリジナル画像とウォータマークが付された画像との離散サンプルシフト毎の相関結果を示すグラフ図である。
【図６】図６Ａはオリジナル画像Ｉのオーバサンプリングされたバージョンに対応するグラフ図であり、図６Ｂはウォータマークが付された画像Ｗ’のオーバサンプリングされたバージョンに対応するグラフ図であり、図６Ｃはオーバサンプリングされたオリジナル画

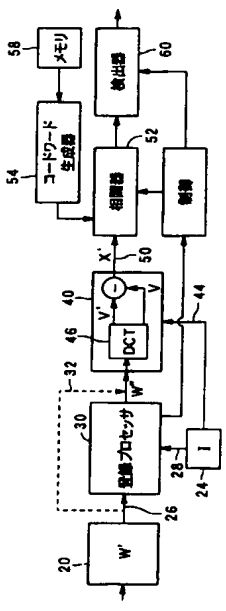
像とウォータマークが付された画像との離散サンプルシフト毎の相関結果を示すグラフ図である。

【図７】ウォータマークが付された画像におけるオリジナル画像には存在しない部分をオリジナル画像の対応する部分に置換する登録画像の前処理を説明する図である。

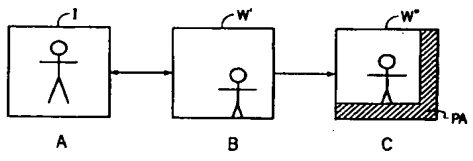
【図１】



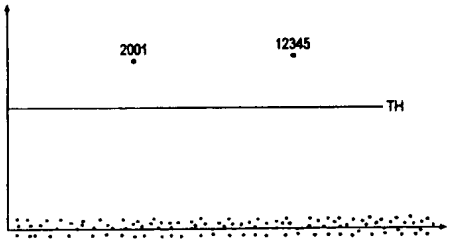
【図２】



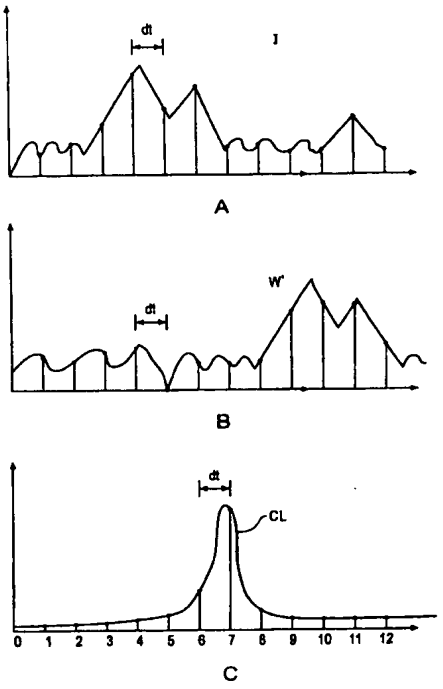
【図３】



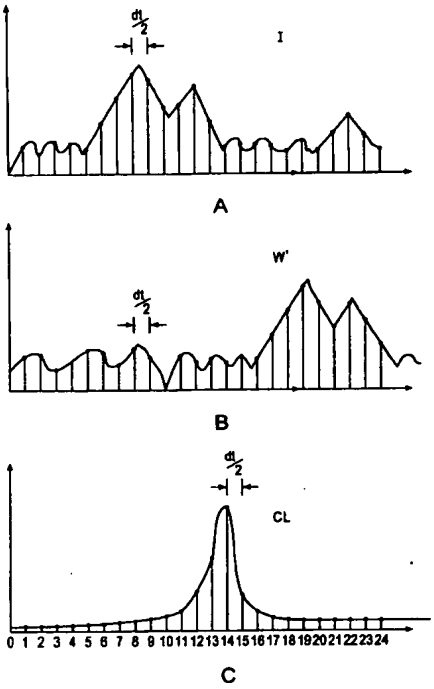
【図４】


2001
12345
TH

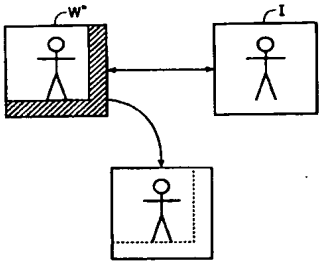
【図５】


dt
I
A
W'
dt
B
dt
CL
0 1 2 3 4 5 6 7 8 9 10 11 12
C

【図６】


dt/2
I
A
W'
dt/2
B
dt/2
CL
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
C

【図７】


W'
I

フロントページの続き

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5C078 BA57 CA14 CA47

【外国語明細書】

1 Title of Invention

DATA PROCESSING APPARATUS AND METHOD

2 Claims

1. A detecting data processing apparatus operable to identify one or more of a predetermined set of code words present in a marked version of an original material item, said marked version having been formed by combining each of a plurality of samples of said original material item with one of a corresponding plurality of code word coefficients, said apparatus comprising

a registering processor operable to associate samples of said marked version of said material item with corresponding samples from said original material item to which corresponding code word coefficients may have been combined,

a recovery processor operable to generate a recovered code word by comparing corresponding samples of said original material item with said samples of said marked material version,

a correlation processor operable to generate, for each of said code words in said predetermined set of code words a correlation value by correlating the recovered code word with each of the generated code words, and

a detection processor operable to detect said one or more code words from the correlation value for the code word exceeding a predetermined threshold.

2. A detecting data processing apparatus as claimed in Claim 1, wherein said registering processor is operable

to form a representation of a correlation of the samples of said original material item and the samples of said marked version, for each of a plurality of respective shifts of said original material item with respect to said marked version of said material item, and

to determine a first registration position of said original material item with respect to said marked material item, from the respective shift producing the highest correlation value, wherein said registering processor is operable

to over sample said original material item and said marked version of said material item,

to form said representation of the correlation of the over sampled versions of said original material item and said marked version, for a plurality of respective shifts with respect to said first registration position, and

to determine a second registration position from the respect shift of said over-sampled versions having the highest correlation value.

3. A detecting data processing apparatus as claimed in Claim 1 or 2, wherein said registration processor is operable

to calculate a difference between each sample of said original material item and the corresponding sample of said marked copy of said material item with respect to said second registered position,

to compare the difference with a pre-determined threshold and if said difference is greater than said threshold, to replace said samples of said registered marked material item with said samples of said original material item.

4. A detecting data processing apparatus as claimed in any preceding Claim, wherein said correlation processor includes a code word generator operable to generate pseudo-random numbers from which said regenerated code word coefficients are formed, said pseudo-random numbers being generated from a seed value, said seed value being formed from the samples of said marked material item.

5. A detecting data processing apparatus as claimed in any preceding Claim, wherein said code word has been introduced into said material item in the discrete cosine transform domain, said apparatus comprising

a discrete cosine transform processor operable to transform said marked material item and said original material item into the discrete cosine transform domain, wherein said recovery processor is operable to generate said recovered code word by subtracting corresponding discrete cosine transform coefficients of said original material version from discrete cosine transform coefficients of said marked material version.

6. An encoding data processing apparatus for generating at least one marked version of an original item of material by introducing one of a predetermined set of code words into a copy of said original material item, said apparatus comprising,

a code word generator operable to form said code word from said predetermined set of said code words having a plurality of code word coefficients, and

an encoding processor operable to combine each of the code word coefficients with one of a corresponding plurality of samples from said original material item to form said marked version of said material item, wherein

said code word is generated using a pseudo-random number generator initialised with a seed value uniquely associated with said code word, said code word coefficients being formed from numbers generated by said pseudo-random number generator.

7. An encoding data processor according to Claim 6, comprising a code word generator operable to generate said seed value from the samples of said material item.

8. An encoding data processing apparatus as claimed in Claim 6 or 7, comprising

a discrete cosine transform processor operable to transform said material item into the discrete cosine transform domain, said material item in said discrete cosine transform domain being represented as a plurality of discrete cosine transform coefficients, wherein said encoding processor is operable to combine said code word with said material item by adding each of said code word coefficients to a corresponding one of said discrete cosine transform coefficients, and

an inverse discrete cosine transform processor operable to form said marked copy of said material item by performing an inverse discrete cosine transform on said discrete cosine transform image to which said code word has been added by said encoding processor.

9. A cinema projector including an encoding data processing apparatus according to Claim 6, 7 or 8, wherein said data processing apparatus is operable to

receive at least one of audio signals and image signals before reproduction, and to introduce a code word into said at least one of audio signals and image signals before reproduction.

10. A web server operable to provide material items for downloading via the Internet, said web server including an encoding data processing apparatus according to Claim 6, 7 or 8, wherein said data processing apparatus is operable to receive material items and to introduce a code word into said material items before said material items are downloaded.

11. A system for identifying the recipient of a material item, said system comprising

an encoding data processor according to Claim 6, 7 or 8, operable to generate said marked material item by introducing a code word generated from a seed uniquely identifying said recipient, and

a detecting data processor according to any of claims 1 to 6, operable to detect with a predetermined false positive probability the recipient by detecting the presence or absence of the code word in said material.

12. A method of identifying one or more of a predetermined set of code words present in a marked version of an original material item, said marked version having been formed by combining each of a plurality of samples of a copy of said original material item with one of a corresponding plurality of code word coefficients, said method comprising

associating samples of said version of said material item with corresponding samples from said original material item to which corresponding code word coefficients may have been added,

generating a recovered code word by subtracting corresponding samples of said original material item from said samples of said marked material item,

generating, for each of said plurality of code words, a correlation value by correlating the recovered code word with each of the plurality of code words, and

detecting said at least one code word from the correlation value for the code word exceeding a predetermined threshold.

13. A method of generating at least one marked version of an original item of material by introducing one of a predetermined set of code words into a copy of said original material item, said method comprising,

forming said code word from said predetermined set of said code words by from a plurality of code word coefficients, and

combining each of the code word coefficients with a different one of a corresponding plurality of samples from said original material item, to form said marked material item, wherein said forming said code word comprises

initialising a pseudo-random number generator in accordance with a seed value uniquely associated with said code word, and

forming said code word coefficients from numbers generated by said pseudo-random number generator.

14. A data signal representing a material item to which a code word has been added by the data processing apparatus according to any of Claims 6, 7 or 8.

15. A data carrier having recorded thereon a data signal according to Claim 14.

16. A computer program providing computer executable instructions, which when loaded onto a data processor configures the data processor to operate as the detecting data processing apparatus according to any of Claims 1 to 5 or the encoding data processor according to any of Claims 6, 7 or 8.

17. A computer program providing computer executable instructions, which when loaded on to a data processor causes the data processor to perform the method according to Claim 12 or 13.

18. A computer program product having a computer readable medium having recorded thereon information signals representative of the computer program claimed in any of Claims 16 or 17.

19. A receiver operable to receive signals representative of material items, comprising

an encoding data processing apparatus according to Claims 6, 7 or 8, operable to combine at least one code word with the received signals, said code word being provided to identify uniquely said received signals.

20. A detecting or an encoding data processing apparatus as herein before described with reference to the accompanying drawings.

21. A method of identifying at least one of a predetermined set of code words or a method of generating at least one marked copy of an original item of material as herein before described with reference to the accompanying drawings.

3 Detailed Description of Invention

Field of Invention

The present invention relates to encoding data processing apparatus and methods, which are arranged to embed code words into versions of material items. In some applications the code words are used to uniquely identify the material items.

Correspondingly, the present invention also relates to data processing apparatus and methods operable to detect one or more code words, which may be present in a material item.

Background of the Invention

A process in which information is embedded in material for the purpose of identifying the material is referred to as watermarking.

Identification code words are applied to versions of material items for the purpose of identifying the version of the material item. Watermarking can provide, therefore, a facility for identifying a recipient of a particular version of the material. As such, if the material is copied or used in a way, which is inconsistent with the wishes of the distributor of the material, the distributor can identify the material version from the identification code word and take appropriate action.

In this description, an item of material, which is copied or used in a way, which is inconsistent with the wishes of the originator, owner, creator or distributor of the material, will be referred to for convenience as an offending item of material or offending material.

The material could be any of video, audio, audio/video material, software programs, digital documents or any type of information bearing material.

For a watermarking scheme to be successful, it should be as difficult as possible for the users to collude in order to mask or remove the identification code words. It should also be as difficult as possible for users to collude to alter the identification code word to the effect that one of the other users is falsely indicated as the perpetrator of an offending item of material. Such an attempt by users to collude to either mask the code word or alter the code word to indicate another user is known as a collusion attack.

Any watermarking scheme should be arranged to make it difficult for users receiving copies of the same material to launch a successful collusion attack. A watermarking scheme should therefore with high probability identify a marked material item, which has been the subject of a collusion attack. This is achieved by identifying a code word recovered from the offending material. Conversely, there should be a low probability of not detecting a code word when a code word is present (false negative probability). In addition the probability of falsely detecting a user as guilty of taking part in a collusion attack, when this user has not taken part, should be as low as possible (false positive probability).

US Patent Serial No. 5, 664, 018 discloses a watermarking process in which a plurality of copies of material items are marked with a digital watermark formed from a code word having a predetermined number of coefficients. The watermarked material item is for example an image. The apparatus for introducing the watermark transforms the image into the Discrete Cosine Transform (DCT) domain. The digital watermark is formed from a set of randomly distributed coefficients having a normal distribution. In the DCT domain each code word coefficient is added to a corresponding one of the DCT coefficients. The watermarked image is formed by performing an inverse DCT. A related publication entitled "Resistance of Digital Watermarks to Collusion Attacks", by J. Kilian, F. T. Leighton et al, published by MIT, July 27, 1998, provides a detailed mathematical analysis of this watermarking process to prove its resistance to attack.

Summary of Invention

According to an aspect of the present invention there is provided a detecting data processing apparatus operable to identify at least one of a predetermined set of code words present in a marked version of an original material item. The marked version is formed by combining each of a plurality of samples of the original material item with one of a corresponding plurality of code word coefficients. The detecting apparatus comprises a registering processor operable to associate samples of the marked version of the material item with corresponding samples from a copy of the original material item to which samples corresponding code word coefficients may have been added. The detecting processor also comprises a recovery processor

operable to generate a recovered code word by subtracting corresponding samples of the original material item from the samples of the marked material version, a correlation processor operable to generate, for each of the code words in the predetermined set of code words, a correlation value by correlating the recovered code word with each of the code words, and a detection processor operable to detect one or more code words from the correlation value for the code word exceeding a predetermined threshold.

According to a second aspect of the invention there is provided an encoding data processing apparatus for generating at least one marked copy of an original item of material by introducing one of a predetermined set of code words into a copy of the original material item. The apparatus comprises a code word generator operable to form the code word from the predetermined set of the code words by generating a plurality of code word coefficients. The apparatus includes an encoding processor operable to combine each of the code word coefficients with one of a corresponding plurality of samples from the original material item to form the marked version of the material item. The code word generator includes a pseudo-random number generator. The code word generator is operable to initialise the pseudo-random number generator in accordance with a seed value uniquely associated with the code word, and to form the code word coefficients from numbers generated by the pseudo-random number generator.

The present invention aims to provide a practical watermarking system, which utilises code words having coefficients which are randomly distributed as proposed as in US 5,664,018. The present invention utilises a pseudo-random number generator forming part of a detecting data processor and an encoding data processor. The random number uses a seed value, which determines the sequence of numbers, produced by the number generator. As such the seed value is uniquely associated with the watermarked copy in which the code word produced from the seed value is present. The seed value therefore provides a convenient facility for identifying the marked copy.

The detection processor according to the present invention is provided with a registration processor. The registration processor provides a further advantage. By registering the marked copy of the material item with respect to the original copy of

the material item, the likelihood of detecting the presence of a code word will be improved, reducing the false negative probability. This is because the code word will be more likely to be recovered since the samples of the marked material item will be more likely to correspond with the samples of the original material item.

In preferred embodiments the seed value of the code word is derived from the values of the samples of the original material item. An advantage is thereby provided because it is not necessary to communicate the seed value for each code word between the encoding and the detecting data processing apparatus.

Various further aspects and features of the present invention are defined in the appended claims.

Description of Preferred Embodiments

Watermarking System Overview

An example embodiment of the present invention will now be described with reference to protecting video images. The number of users to which the video images are to be distributed determines the number of copies. To each copy an identification code word is added which identifies the copy assigned to one of the users.

Video images are one example of material, which can be protected by embedding a digital code word. Other examples of material, which can be protected by embedding a code word, include software programs, digital documents, music, audio signals and any other information-bearing signal.

An example of an encoding image processing apparatus, which is arranged to introduce an identification code word into a copy of an original image, is shown in Figure 1. An original image *I* is received from a source and stored in a frame store 1. This original image is to be reproduced as a plurality of water marked copies, each of which is marked with a uniquely identifiable code word. The original image is passed to a Discrete Cosine Transform (DCT) processor 2, which divides the image into 8 x 8 pixel blocks and forms a DCT of each of the 8x8 pixel blocks. The DCT processor 2 therefore forms a DCT transformed image *V*.

In the following description the term "samples" will be used to refer to discrete samples from which an image (or indeed any other type of material) is comprised. The samples may be luminance samples of the image, which is otherwise, produced from the image pixels. Therefore, where appropriate the terms samples and pixels are inter-changeable.

The DCT image *V* is fed to an encoding processor 4. The encoding processor 4 also receives identification code words from an identification code word generator 8.

The code word generator 8 is provided with a plurality of seeds, each seed being used to generate one of the corresponding code words. Each of the generated code words may be embedded in a copy of the original image to form a watermarked image. The code word generator 8 is provided with a pseudo random number generator. The pseudo random number generator produces the code word coefficients to form a particular code word. In preferred embodiments the coefficients of the code

words are generated in accordance with a normal distribution. However, the coefficients of the code word are otherwise predetermined in accordance with the seed, which is used to initialise the random number generator. Thus for each code word there is a corresponding seed which is stored in a data store 12. Therefore it will be understood that to generate the code word X^i, $seed_i$ is retrieved from memory 12 and used to initialise the random number generator within the code word generator 8.

In the following description the DCT version of the original image is represented as V, where;

$$V = \{v_i\} = \{v_1, v_2, v_3, v_4, \ldots\ldots\ldots\ldots v_N\}$$

and v_i are the DCT coefficients of the image. In other embodiments the samples of the image v_i could represent samples of the image in the spatial domain or in an alternative domain.

Each of the code words X^i comprises a plurality of n code word coefficients, where;

$$X^i = \{x^i_j\} = \{x^i_1, x^i_2, x^i_3, x^i_4, \ldots\ldots\ldots\ldots x^i_n\}$$

The number of code word coefficients n corresponds to the number or samples of the original image V. However, a different number of coefficients is possible, and will be determined in dependence upon a particular application.

A vector of code word coefficients X^i forming the i-th code word is then passed via channel 14 to the encoder 4. The encoder 4 is arranged to form a watermarked image W_i by adding the code word X^i to the image V. Effectively, therefore, as represented in the equation below, each of the code word coefficients is added to a different one of the coefficients of the image to form the watermark image W_i.

$$W^i = V + X^i$$

$$W^i = v_1 + x^i_1, v_2 + x^i_2, v_3 + x^i_3, v_4 + x^i_4, \ldots\ldots\ldots\ldots, v_n + x^i_n$$

As shown in Figure 1, the watermarked images W_i are formed at the output of the image processing apparatus by forming inverse DCT of the image produced at the output of the encoding processor 4 by the inverse DCT processor 18.

Therefore as represented in Figure 1 at the output of the encoder 4 a set of the watermarked images can be produced. For a data word of up to 20-bits, one of 10 000 000 code words can be selected to generate 10 million watermarked W_i versions of the original image I.

Although the code word provides the facility for uniquely identifying a marked copy W_i of the image I, in other embodiments the 20 bits can provide a facility for communicating data within the image. As will be appreciated therefore, the 20 bits used to select the identification code word can provide a 20 bit pay-load for communicating data within the image V.

The encoding image processing apparatus which is arranged to produce the watermarked images shown in Figure 1 may be incorporated into a variety of products for different scenarios in which embodiments of the present invention find application. For example, the encoding image processing apparatus may be connected to a web site or web server from which the watermarked images may be downloaded. Before downloading a copy of the image, a unique code word is introduced into the downloaded image, which can be used to detect the recipient of the downloaded image at some later point in time.

In another application the encoding image processor forms part of a digital cinema projector in which the identification code word is added during projection of the image at, for example, a cinema. Thus, the code word is arranged to identify the projector and the cinema at which the images are being reproduced. Accordingly, the identification code word can be identified within a pirate copy produced from the images projected by the cinema projector in order to identify the projector and the cinema from which pirate copies were produced. Correspondingly, a watermarked image may be reproduced as a photograph or printout in which a reproduction or copy may be made and distributed. Generally therefore, the distribution of the watermarked images produced by the encoding image processing apparatus shown in Figure 1 is represented by a distribution cloud 19.

Detecting Processor

A detecting image processing apparatus which is arranged to detect one or more of the code words, which may be present in an offending marked image is shown

in Figure 2. Generally, the image processor shown in Figure 2 operates to identify one or more of the code words, which may be present in an offending, copy of the image.

The offending version of the watermarked image W' is received from a source and stored in a frame store 20. Also stored in the frame store 24 is the original version of the image I, since the detection process performed by the image processor requires the original version of the image. The offending watermarked image W' and the original version of the image are then fed via respective connecting channels 26, 28 to a registration processor 30.

As already explained, the offending version of the image W' may have been produced by photographing or otherwise reproducing a part of the watermarked image W^i. As such, in order to improve the likelihood of detecting the identification code word, the registration processor 30 is arranged to substantially align the offending image with the original version of the image present in the data stores 20 and 24. The purpose of this alignment is to provide a correspondence between the original image samples I and the corresponding samples of the watermarked image W^i to which the code word coefficients have been added.

The effects of the registration are illustrated in Figure 3. In Figure 3 an example of the original image I is shown with respect to an offending marked version of the image W'. As illustrated in Figure 3, the watermarked image W' is offset with respect to the original image I and this may be due to the relative aspect view of the camera from which the offending version of the watermarked image was produced.

In order to recover a representation of the code word coefficients, the correct samples of the original image should be subtracted from the corresponding samples of the marked offending image. To this end, the two images are aligned. As shown in Figure 3, the registered image W'' has a peripheral area PA which includes parts which were not present in the original image.

As will be appreciated in other embodiments, the registration processor 30 may not be used because the offending image W' may be already substantially aligned to the originally version of the image I, such as, for example, if the offending version was downloaded via the Internet. Accordingly, the detecting image processor is provided

with an alternative channel 32, which communicates the marked image directly to the recovery processor 40.

The registered image W'' is received by a recovery processor 40. The recovery processor 40 also receives a copy of the original image I via a second channel 44. The registered image W'' and the original image I are transformed by a DCT transform processor 46 into the DCT domain. An estimated code word X' is then formed by subtracting the samples of the DCT domain marked image V' from the DCT domain samples of the original image V as expressed by the following equations:

$$X' = V' - V$$
$$= v_1' - v_1, v_2' - v_2, v_3' - v_3, v_4' - v_4, \ldots\ldots, v_n' - v_n,$$
$$= x_1', x_2', x_3', x_4', \ldots\ldots x_n'$$

The output of the recovery processor 40 therefore provides on a connecting channel 50 an estimate of the coefficients of the code word which is to be identified. The recovered code word X' is then fed to a first input of a correlator 52. The correlator 52 also receives on a second input the regenerated code words X^i produced by the code word generator 54. The code word generator 54 operates in the same way as the code word generator 8 which produces all possible code words of the set, using the predetermined seeds which identify uniquely the code words from a store 58.

The correlator 52 forms n similarity $sim(i)$ values. In one embodiment, the similarity value is produced by forming a correlation in accordance with following equation:

$$sim(i) = \frac{X^i \cdot X'}{\sqrt{X^i \cdot X'}} = \frac{x_1^i \cdot x_1' + x_2^i \cdot x_2' + x_3^i \cdot x_3' + \ldots\ldots + x_n^i \cdot x_n'}{\sqrt{x_1^i \cdot x_1' + x_2^i \cdot x_2' + x_3^i \cdot x_3' + \ldots\ldots + x_n^i \cdot x'}}$$

Each of the n similarity values $sim(i)$ is then fed to a detector 60. The detector 60 then analyses the similarity values $sim(i)$ produced for each of the n possible code words. As an example, the similarity values produced by the correlator 52 are shown in Figure 4 with respect to a threshold TH for each of the possible code words. As shown in Figure 4, two code words are above the threshold, 2001, 12345. As such, the detecting processor concludes that the watermarked version associated with code word 2001 and code word 12345 must have colluded in order to form the offending image. Therefore, in accordance with a false positive detection probability, determined from

the population size, which in this case is 10 million and the watermarking strength α, the height of the threshold *TH* can be set in order to guarantee the false detection probability. As in the example in Figure 4, if the similarity values produced by the correlator 52 exceed the threshold then, with this false positive probability, the recipients of the marked image are considered to have colluded to form the offending watermarked version of the image W^i.

The following sections provide illustrations of advantages and features of the operation of the watermarking system illustrated in Figures 1 and 2.

Registration

The process of aligning the offending marked version of the image with the copy of the original image comprises correlating the samples of the original image with respect to the marked image. The correlation is performed for different shifts of the respective samples of the images. This is illustrated in Figure 5.

Figure 5A provides an illustration of discrete samples of the original image *I*, whereas Figure 5B provides an illustration of discrete samples of the offending watermarked image *W'*. As illustrated in the Figures 5A and 5B, the sampling rate provides a temporal difference between samples of *dt*. A result of shifting each of the sets of samples from the images and correlating the discrete samples is illustrated in Figure 5C.

As shown in Figure 5C, for a shift of between 6 and 7 samples, the correlation peak is highest. However, as illustrated by the continuous line *CL* formed between the samples, the actual peak shift of the original image with respect to the offending watermarked image, falls between 6 and 7 samples.

In preferred embodiments, the registration processor is operable, following the detection of a first registration position, to detect a second registration position, which is refined with respect to first registration position. To this end, the registration processor 30 operates as illustrated in Figure 6. Figures 6A and 6B show the original image *I* and the watermarked offending image *W'*, but over sampled to twice the sampling rate. Correspondingly, therefore, the difference between successive samples is *dt*/2. As can be seen in Figure 6C, the peak value of the correlation between the over-sampled versions of the original image and the offending watermarked image

falls at 12 samples, which corresponds to an approximate position of the peak of the correlation output. It will therefore be appreciated that the registration processor 30 is able to provide a more accurate registration of the two images by performing the second registration process for the over-sampled version of the original and marked images.

A further advantage provided by the registration processor shown in Figure 2 is illustrated in Figure 7. In Figure 7 the registered image W'', which has been reproduced from Figure 3, is shown with respect to the original image I. In order to improve the likelihood of detecting the code word within the offending watermarked image W'', the parts of the original image not present in the watermarked image, shown as the peripheral area PA are replaced by corresponding parts of the original image. This is effected by comparing the mean absolute difference between the samples of the original image and the offending watermarked image and if this difference exceeds a predetermined threshold, then the samples of the offending watermarked image are simply replaced by corresponding samples from the original image. This provides a particular advantage in the detection process formed by the correlator 52 in combination with the detector 60. This is because, if the parts of the marked image PA, which were not present in the original image, are used to form recovered code word coefficients these coefficients will not correlate with the reproduced version of the code word. These coefficients can produce large values, causing significant noise in the correlation sum $sim(i)$. As such, there will be a reduced likelihood of the correctly identified code word being above the threshold TH for detecting code words in the detector 60. Replacing the parts of the offending image with the corresponding parts from the original image, therefore reduces the likelihood of a false negative detection, by effectively setting the corresponding correlation terms to zero.

Code Word Generation

A further advantageous aspect of the embodiment shown in Figures 1 and 2 is provided by generating the seed of the random number from which the code word is produced from the source image samples. This is affected by analysing the DCT coefficients of the image to be watermarked and from these coefficients, generating the

seed to be used to generate the code word. This can be effected, for example, by using a hashing algorithm known to those skilled in the art as "secure hashing algorithm 1" (sha-1). This algorithm forms an ANSI standard (ANSI x9.30-2). This algorithm is referred to in a book entitled "Handbook of applied cryptography" by A.J. Menezes. As such the seed from the random number can be generated and determined in the encoding image processor and the detecting image processor from the DCT coefficients.

Other Applications

In addition to the above-mentioned applications of the encoding data processing apparatus of the watermarking system to a cinema projector and to a web server, other applications are envisaged. For example, a receiver/decoder is envisaged in which received signals are watermarked by introducing code words upon receipt of the signals from a communicating device. For example, a set top box is typically arranged to receive television and video signals from a "head-end" broadcast or multi-cast device. As will be appreciated in this application, the encoding data processing apparatus forms part of the set top box and is arranged to introduce watermark code words into the video signals as the signals are received and decoded. In one example embodiment, the watermark code word is arranged to uniquely identify the set top box which receives and decodes the video signals.

In a further embodiment a digital cinema receiver is arranged to receive a digital cinema film via a satellite. The receiver is arranged to receive signals representing the digital cinema film and to decode the signals for reproduction. The receiver includes an encoding data processing apparatus, which introduces a watermark code word into the decoded film signals. The watermark code word is provided, for example, to uniquely identify the cinema receiving the film signals.

A further example embodiment may comprise a digital camera or camcorder or the like which includes a memory and a memory controller. An encoding data processing apparatus according to an embodiment of the present invention is arranged to introduce a watermark code word stored in the memory into video signals captured by the camera. According to this embodiment, the encoding data processing apparatus does not include a code word generator because the code word is pre-stored in the

memory. Under the control of the memory controller the code word stored in the memory is embedded into the video signals, uniquely or quasi-uniquely identifying the video signals.

In a further embodiment, an encoding data processing apparatus according to an embodiment of the invention is operable encoded a sequence of watermark code words into different frames of digital images forming a continuous or moving picture. The code words may be related to one another and may be used to identify each of the images separately.

Various further aspects and features of the present invention are defined in the appended claims. Various modifications can be made to the embodiments herein before described without departing from the scope of the present invention.

4 Brief Description of Drawings

Figure 1 is a schematic block diagram of an encoding image processing apparatus;

Figure 2 is a schematic block diagram of a detecting image processing apparatus;

Figure 3A is a representation of an original image, Figure 3B is a representation of a marked image and Figure 3C is the marked image after registration;

Figure 4 is a graphical representation of an example correlation result for each of a set of N code words;

Figure 5A is a graphical representation of samples of the original image I, Figure 5B is a graphical representation of samples of the watermarked image W'; Figure 5C is a graphical representation of correlation results for the original image and the watermarked image with respect to discrete sample shifts;

Figure 6A is a graphical representation of an over-sampled version of the original image I; Figure 6B is a graphical representation of an over-sampled version of the watermarked image W'; Figure 6C is a graphical representation of correlation results for the over-sampled original image and the watermarked image with respect to discrete sample shifts; and

Figure 7 is a representation illustrating pre-processing of the registered marked image with the effect of replacing parts of the marked image not present in the original image with corresponding parts of the original image.

1 Abstract

A watermarking system comprises an encoding data processor operable to generate at least one marked version of an original item of material by introducing one of a predetermined set of code words into a copy of the original material item. The code words are generated from a pseudo-random number generator initialised to a seed value. The seed value is used to identify the marked material item, from the code word produced from the seed valuc. The watermarking system also includes a detecting data processor operable to identify a particular marked copy of the material item by rccovering a code word from the marked material item and correlating all code words in the set of code words with the recovered code word. The detecting data processing apparatus also includes a registration processor operable to associate samples of the original material item with corresponding samples of the marked material item to which corresponding code word coefficients may have been added. By registering the original material item with the marked material item, a likelihood of correctly identifying the version of the marked material item is improved, reducing a false negative detection probability.

2 Representative Drawing

Fig 1

【図1】

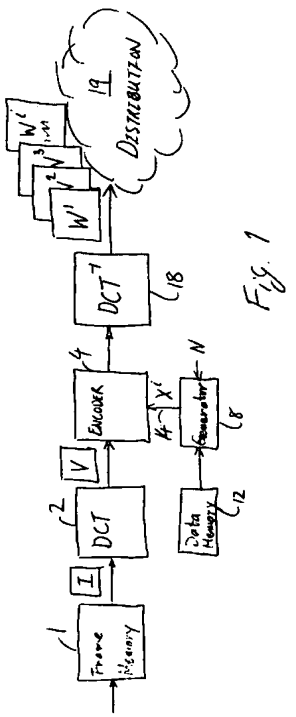

Fig. 1

【図2】

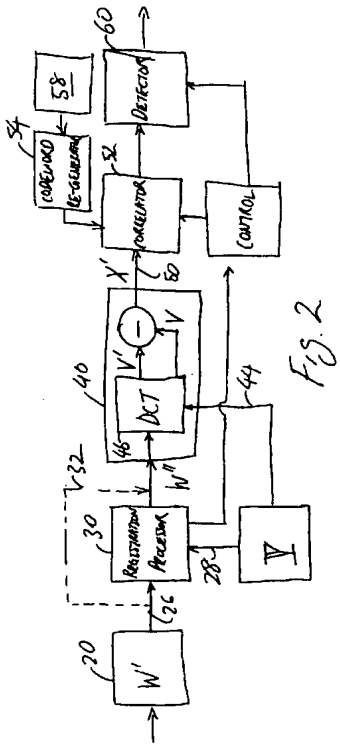

Fig. 2

【図3】

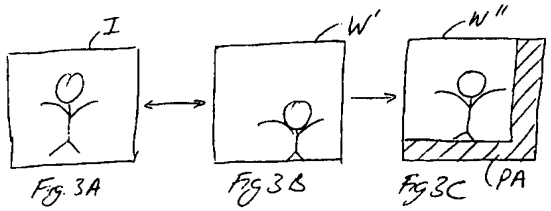

Fig 3A Fig 3B Fig 3C

Fig 3

【図4】

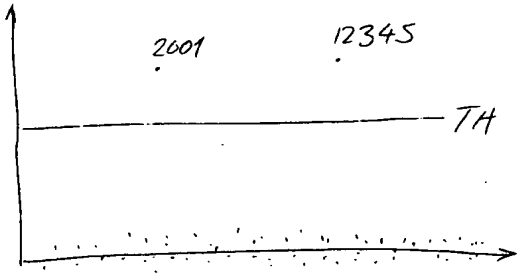

Fig. 4

【図5】

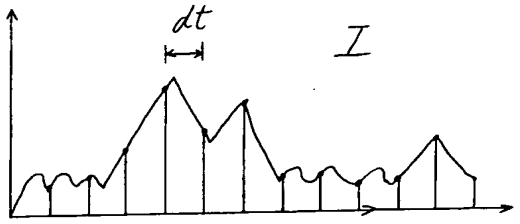

Fig. 5A

【図6】

Fig 5B

【図7】

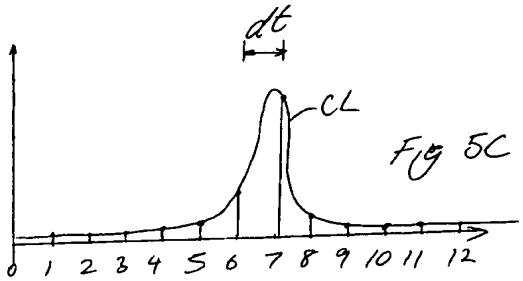

Fig 5C

【図8】

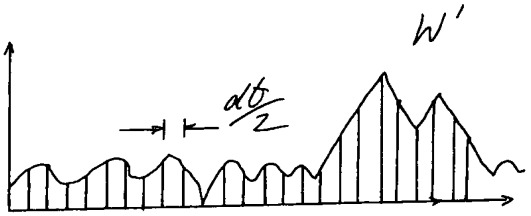

Fig 6B

【図10】

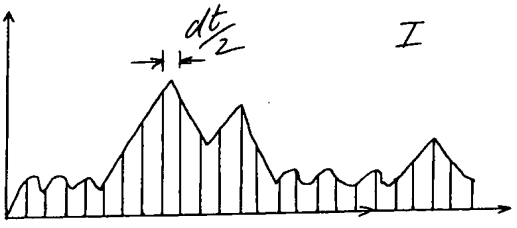

Fig 6A

【図9】

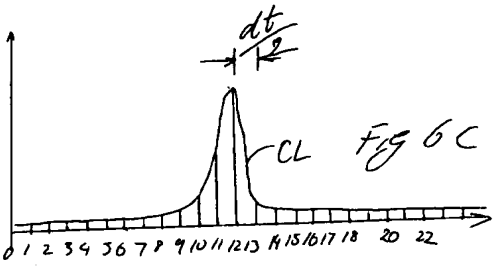

Fig 6C

【図11】

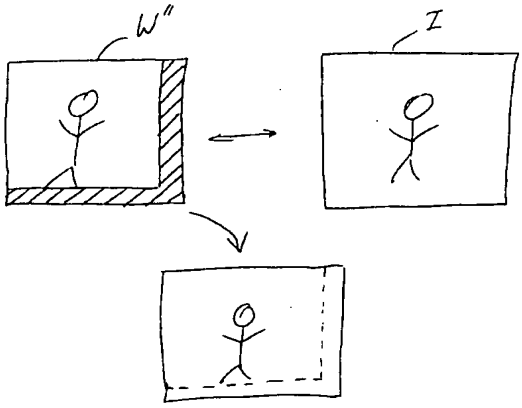

Fig. 7